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THE ELECTRICIAN:

A WEEKLY JOURNAL OF

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No. 1.—Vol. XV. FRIDAY, MAY 15, 1885. Price 4d.

NOTES.

The Hipp Microphone.—A lengthy description of the Hipp microphone appears in the *Schweizerische Bauzeitung.*

Notices of Interruption.—Telegraphic communication with Venezuela is interrupted. The cable between Maranham and Para is interrupted.

The Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended 8th inst. amounted to £3,115.

The Telephone in Spain.—Telephonic communication is about to be established between the Palace of the Mayor and the Hôtel de Ville at Barcelona.

The Eastern Telegraph Company.—This company notify the opening of a new branch West-End Station at 42, Parliament-street, Westminster.

Inventors' Institute, Lonsdale Chambers, Chancery-lane.—On Monday, 28th May, at 8 p.m., a Paper will be read "On Electric Tram Cars," by A. Reckenzaun, Esq.

An Electrical Sewing Machine.—The *Moniteur Industriel* announces the invention of an electrical sewing machine, in which the different parts are moved by electro-magnets.

The Telegraph to Merv.—The Tirpul correspondent of the *Daily Telegraph* is informed that the telegraph is completed to Sarakhs, and a branch is being laid from Kakraha to Merv.

The Electric Light in Milan.—Among projected installations we notice that the Ospedale Maggiore, the Palazzo, Marino, and the Galleria Vitt. Em. in Milan are to be lighted electrically.

Opening of a New Station in China.—The Eastern Telegraph Company notify the opening of a new telegraph station in China—Yamchow—the rate from Great Britain being 10s. per word.

The International Convention.—The International Convention for the protection of submarine telegraph cables, which was signed at Paris on March 14th, was issued on Saturday last as a Parliamentary paper.

The Force Exerted by an Electric Spark.—M. Gaston Planté has almost terminated a series of experiments demonstrating the nature of the mechanical force that the spark of a rheostatic machine is able to exercise.

The Electric Light in Berlin.—The Royal Library at Berlin is to be experimentally lighted by electricity, and kept open a couple of hours later nightly, to enable the public to form an opinion upon the innovation.

The Electric Light at the Opera House, Paris.—The electric light in the body of the hall at the Opera, Paris, which failed on a previous occasion, gave great satisfaction at the second performance of "Tabarin."

The Telephone in Marseilles.—The subscribers to the telephone exchange in Marseilles are now permitted to both send and receive their telegrams by telephone upon paying a supplementary tax of 50 francs per annum.

Change of Address.—The address of the Indo-European Telegraph Company in Manchester is changed to 60, Spring-gardens. Offices have also been opened at 9, East India-avenue, and at 10 and 11, Mincing-lane, E.C.

Development of Electricity in the Filtration of Mercury.—In filtering mercury by means of the Pfaundler apparatus M. J. Dechant has recognised that a sensible quantity of electricity is developed during the operation.

Dynamos for the War Department.—The Anglo-American Brush Electric Light Corporation has received orders to supply, by the first week in July, 23 of their compound wound slow-speed dynamos for use in submarine mining.

The Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 8th May were £2,456, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

Temporary Electric Lighting.—On the occasion of a dance given by Lady Mills, on the 6th inst., the reception and other rooms were lit by the electric light. The installation was carried out for Mr. F. G. Howard by the Electrical Power Storage Company.

The Electric Light in Ohio.—At Dayton, in the State of Ohio, in America, there are 515 subscribers to the telephone out of 50,000 inhabitants. The town is lighted by 200 Fuller arc lamps, and it is also proposed to construct a central station for incandescent lighting.

The Dream of Paris.—The discussion upon the project of MM. Bourdais and Sebillot of illuminating the whole world by means of 500,000 billions of arc lamps on the top of a big stick in Paris commenced last week at a meeting of the members of the Société des Ingénieurs Civils.

Electric Lighting at a Ball.—On the 6th inst. the Electrical Power Storage Company carried out a large temporary installation for Mr. S. Montague, of 12, Kensington Palace-gardens, the whole of the reception rooms, conservatories, and passages being lit by over 120 lamps of 20 candle-power.

Influence of Light on the Electrical Resistance of Metals.—From a series of elaborate experiments made in the Yale College Laboratory on plates of platinum, gold, and silver, it has been concluded that if light causes any diminu-

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tion in the electrical resistance of metals, it probably does not exceed a few thousandths of 1 per cent.

THE LATE SIR W. SIEMENS.—A lecture was recently delivered in Firth College, under the auspices of the Literary and Philosophical Society, in reference to the career and inventions of the late Sir Charles William Siemens, by Mr. W. Carpenter, B.A., B.Sc., &c., Manager of the School of Submarine Telegraphy and Electrical Engineering, London.

TELEGRAMS.—Mr. Lefevre informed Mr. W. Lawrence that there was no intention to make any change in the present practice with regard to telegrams, which was that, when the message could not be delivered, an official message was sent to the office of origin ; and if the sender was not within the limits of that delivery, intimation was sent to him by first post.

ELECTRICITY AT LIMOGES.—The manufacturers and tradesmen of Limoges have nominated a committee to report upon the electric lighting of the town. The principal points to be established will be the price of each lamp of 10 candles according to whether 1,000, 2,000, or 3,000 lamps are used, and the nature of the guarantee for the regularity and fixity of the light.

PERSONAL.—At a special meeting of the Salford School Board held recently for the purpose of electing a member in the place of Alderman F. H. Walmsley, who has resigned, Mr. Walter T. Glover, electric cable manufacturer, Salford, was elected a member of the Board, and was placed upon the several committees of which Mr. Walmsley had been a member.

COMBINED ARC AND INCANDESCENT LIGHTING.—Some interesting experiments were recently made on an American steamboat in operating arc and incandescent lights from the same dynamo. An improved Edison dynamo was employed and resistance coils introduced to adjust the tension for the two systems. The experiments were said to have been successful.

ELECTRIC LIGHTING OF A FROZEN MEAT STORE.—The contract for the electric lighting of Messrs. Bell and Son's new premises in Charterhouse-street has been given to the Electrical Power Storage Company, of 4, Great Winchester-street. It will doubtless be remembered that this firm lit some time back the cold meat stores belonging to the East and West India Dock Company.

ELECTRICITY AND PHYLLOXERA. — A contemporary is informed that a curious phenomenon is reported from some of the Malaga vineyards, where plants, attacked by the phylloxera and given up as practically dead, have begun to show marked symptoms of vitality, due, it is believed, to the destruction of the insects by gases or "electrical conditions," consequent on the recent earthquakes in the locality.

THE TELEPHONE IN GERMANY.—The progress realised in Germany by the telephone during the last ten months of the year 1884 is as follows :—Additional exchanges 9, additional subscribers 1,953, increased mileage of wire 2,095. The principal exchanges are those of Berlin with 2,178 subscribers, Hamburg with 1,224 subscribers, Frankfort-on-Main with 366, Dresden with 354, Leipzig with 321, Mannheim 254, Cologne 223, Stettin 222, and Magdebourg 194.

THE BICHROMATE CELL.—M. Radiguet has invented a new form of the bichromate of potash cell, which permits of the zincs being lifted out and the two solutions of the battery isolated from each other by a single and simple operation. The Carpentier cell, working with a single solution of bichromate and generating a constant current of 1·5 ampere, is giving great satisfaction. This cell, as is well known, owes its constancy to the fact that circulation of the liquid is kept up.

THE INVENTORIES.—In connection with the lighting of the subway from the railway station to the Inventions Exhibition, we are informed that Messrs. Goolden and Trotter have been temporarily supplying the current to the batteries of the Consolidated Company, whose dynamo was not ready for running. The current has been generated by their Halifax machine, which, being run at 12 per cent. above its normal capacity for 16 hours daily, has had an excellent opportunity of proving its capabilities.

CONTRACT.—The contract for the sup ply of telegraph instruments and batteries, for the next twelve months, to the Manchester, Sheffield and Lincolnshire Railway Company, has been secured by Messrs. Blakey, Emmott and Co., of the Northern Telegraph Works, Halifax. This firm have just issued an illustrated catalogue in three parts—Part I. containing list of railway signal apparatus, resistance coils, and general testing apparatus ; Part II. electric bells, &c. ; and Part III. electric light machinery.

THE VOLUNTEER TELEGRAPHISTS.—One of the volunteer telegraphists for the Soudan, writing of Alexandria, says :—"The houses, as a rule, are very inferior from an architectural point of view ; but the buildings of the General Bank of Egypt, the Post Office, the office of the Eastern Telegraph Company, and others are magnificent, both externally and internally. The Soldiers' and Sailors' Home, too, is worth mentioning. There is at present an addition being made to it, and when completed it will be a grand place indeed."

THE ZANZIBAR-MOZAMBIQUE CABLE.—The duplication of this cable, which is part of the Eastern and South African Company's system, is being actively proceeded with, the ss. "Chiltern" having already arrived on the ground. It has been ascertained that the last fault in this section was due to one of the submarine landslips so common along the East African coast. It will be remembered by many of our readers that two of the three faults in the Mozambique-Delagoa Bay cable were due to the same cause. In order to ensure greater safety the new section will be laid in deep water, at a considerable distance from the dangerous locality.

CURE OF WRITER'S CRAMP.—A very interesting article on this subject by A. de Watteville, M.A., M.D., B.Sc., appears in a recent number of the *Lancet*, in which the author describes some very remarkable results obtained by Mr. Wolff, of Upper Berkeley-street, London, by a combined application of massage, gymnastics, and caligraphic exercises. A very singular cure of writer's cramp in the case of a Liverpool merchant, and another in the case of a lady, are described at length, and in each instance the aggravated character of the disorder and the progress of cure are illustrated by specimens of handwriting.

OVERHEAD WIRES AT BRIGHTON.—After having for a long time declined to allow the Post Office to erect overhead wires in the streets, the Brighton Town Council have given permission to the department to do so. The present permission relates to the crossing of five streets, and the municipal authority stipulate that the wires shall be placed at a distance of not less than 40ft. from the road at the lowest part of the span, and that in the event of any improved method coming into general use for fixing telegraph or telephone wires, for strengthening the lines, or allowing them to be worked underground, or lessening the danger to the public, the Post Office shall adopt it, after six months' notice from the Corporation.

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A SAVING CLAUSE.—In a lighting contract for the Municipality of Liége, the Birmingham of Belgium, it is stipulated that if, in consequence of a new discovery, or an improvement introduced into any system of lighting already known, there should be established by regular concessions in one or more towns of Belgium, Holland, France, England or Germany, having a population of not less than 50,000, a system of lighting both for the public and for private individuals, as good and more economical than gas, and that this superiority, equal to at least 15 per cent., be shown by a trial of three years, the Municipality will have the right, subject to the conditions stated, of adopting the new system of illumination.

LARGE ORDER FOR DYNAMOS FOR THE NAVY.—Twenty of the picket boats which are building for the Admiralty are each to be fitted with engines and dynamos for use with search light projectors. These dynamos and engines have been ordered from the Anglo-American Brush Electric Light Corporation, who have also received instructions to supply similar apparatus for H.M. gunboats "Tees," "Spey," "Tay," "Slaney," "Medena," and "Medway," and for H.M. tugboats "Woodcock" and "Magnet." The dynamos for the picket boats, the tug boats, and three of the gunboats are to be coupled to Willans engines, and the remaining three dynamos for the gunboats to engines manufactured by Messrs Goodfellow and Matthews.

THE TELEGRAPH IN SENEGAL.—The French Colonial Minister is actively occupied on a scheme for the extension of the telegraphic system of Senegal. A new line was opened on the 9th of last February of a length of seventy-five kilometres, between Rufêsque and Joal, the construction of which, despite the difficulties presented by numerous dense forests and rivers, occupied only thirty-three days. We are informed that for the new service it has been decided to substitute the Leclanché form of battery for the Marié-Davy, wihch latter has been up to the present exclusively adopted in Senegal. This measure has been rendered necessary by the deterioration of the Marié-Davy battery under the influence of the constant variations of temperature in Senegal.

ROYAL METEOROLOGICAL SOCIETY.—An ordinary meeting of this society will be held by permission of the Council of the Institution of Civil Engineers at 25, Great George-street, Westminster, on Wednesday, the 20th inst., at 7 p.m., when the following papers will be read:—"The Temperature Zones of the Earth in Connection with its Biological Conditions," by Dr. W. Köppen, Hon.Mem.R.Met.Soc.; "Velocities of Winds and their Measurement," by Lieut.-Colonel H. S. Knight, F.R.Met.Soc., F.R.A.S.; "Note on Mr. C. Harding's Paper on Wind Velocities," by Dr. W. Köppen, Hon.Mem.R.Met.Soc.; "Note on a Peculiar Form of Auroral Cloud Seen in Northamptonshire, 1st March, 1885," by Rev. James Davis (communicated by the President).

ELECTRICAL HEADLIGHTS.—At the annual meeting of the shareholders of the American Electric Headlight Company, held at the Denison House, Indianapolis, on April 21, one of the directors stated that the company had passed the experimental stage. The plant they had now in use weighed about 400lb., and instead of running their engine 1,500 revolutions per minute, they had reduced the speed to 600. A year ago it was thought impossible to sell a full equipment for less than 800 dollars; the price now is 450 dollars. The company had patents covering nearly 300 claims in the United States, and controlled patents in seven foreign countries. The lamp they were now using is the invention of George Pyle, and is the only lamp ever made that is electrically governed, all springs, weights, dash pots, &c., having been dispensed with.

NEW TELEGRAPH STEAMER.—Messrs. R. Napier and Son, Govan, have been successful in their negotiations with the Eastern Extension, Australasia, and China Telegraph Company in reference to the construction of a telegraph ship to take the place of the "Magneta," lost a few weeks ago in the Bay of Biscay. The Messrs. Napier have received orders to proceed at once with the construction of a new vessel, which will be of similar dimensions to the "Magneta"—850 tons, 230ft. long, 32ft. in breadth, and 24ft. deep, and will be supplied with compound engines of 1,400 horse-power, to obtain a speed of 12½ knots. The new vessel, like her predecessor, is intended, and will be specially fitted up, for laying, picking-up, and repairing the submarine cables of the telegraph company for which she is to be built. The new vessel will be built of Scotch steel.

ELECTRO-CHEMICAL EQUIVALENT OF SILVER.—An account has been given of experiments made with a view of determining the electro-chemical equivalent of silver in terms of practical units. The final number expressed in C. G. S. units is $1{\cdot}118 \times 10^{-2}$, a value in accordance with that determined by Kohlrausch; thus in practical units the quantity of silver deposited per ampere per hour is 4·0246 grams. With a view of obtaining a convenient standard of E.M.F., a detailed examination of Clark's cells, which possess the advantage of standing ready for use, and not polarising greatly on the passage of small currents, has been made. The value for the E.M.F., that of the B. A. unit, being 0·9867 ohm, is equal to 1·435 volt, with an extreme range of $\frac{1}{1000}$ during six months, although about ten days are required before the cell reaches its permanent condition.

OVER STUDY.—An inquest was held at Plumstead on Saturday, before Mr. Carttar, coroner, on the body of Walter Edward Burrell, aged 19, who committed suicide at 6, Burrage-road, Plumstead, by shooting himself with a revolver. The father stated that the deceased had been employed by the Brush Electric Light Company, and had of late been studying electricity and kindred subjects, which had injured his health. He left the company and got employment in the Arsenal, but could not bear the noise of the machinery, and took his discharge. On Thursday night he shut himself in his bed room, and a few minutes later the report of firearms was heard, followed by a heavy fall, the young man having shot himself with a five-chambered revolver in the right temple. The jury returned a verdict that "Deceased committed suicide while labouring under temporary insanity induced by over-pressure."

THE NEW HOTEL METROPOLE.—We are informed that the whole of the electroliers for the new Hotel Métropole, numbering between two and three hundred in all, and which are of the most elaborate character in the French and Italian renaissance styles, have been designed, the patterns made, and the whole manufactured in the short space of three weeks at the works of Messrs. B. Verity and Sons, in Covent garden. In the hotel, which is one of the largest in Europe, the electric light is at present used only as far up as the second floor; but when the number of large reception rooms, and the grand corridors, and the exceptionally high-class character of the electroliers is taken into consideration, the work turned out reflects great credit upon everybody concerned. At the opening of the hotel, on Monday next, when a grand military concert will be given in aid of the Egyptian War Fund, the Prince and Princess of Wales will be present.

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THE LAROCHELLE PORTABLE BATTERY.—The title of M. Larochelle's battery has been badly chosen in that its dimensions and weight are sufficiently great to render the word "portable" as applied to it somewhat ridiculous. In a pattern lately shown the battery was contained in a vase of ebonite divided into eight compartments, each containing two small rods of carbon and one of zinc. It is said that eight cells connected in series are capable of furnishing current for 64 candle hours. The constancy of the light is said to be due to the composition of the solution, which composition the inventor has kept secret. A contemporary is informed that the liquid is corrosive, and that india rubber gloves have to be worn by those who have the manipulation of the battery. The zincs and carbons are fixed to a disc, and so arranged that accordingly as they are more or less immersed in the liquid, the light emitted is more or less intense. When not in action they are lifted out of the solution by means of a key similar to that of the ordinary oil lamp.

THE SUBMARINE TELEGRAPH CABLES BILL.—In the House of Lords on Monday last Lord Sudeley moved the second reading of this Bill, which was founded upon a convention which was agreed upon with other Powers in March last year. The Earl of Camperdown was understood to say that he would be glad to hear what the other companies would do in carrying out the same convention. Supposing there were an infraction of the convention, would the other countries take any notice of it? In the event of a war, for instance, what penalty would be inflicted upon the subject of the country who damaged the cable? He hoped that on a future stage of the Bill his noble friend would make a full statement upon the subject of the Bill. The noble earl subsequently added that this was a very important matter, as the time for the ratification of the convention had lapsed, and he would be glad to know what had been done in regard to it. After a few words from Lord Sudeley, referring to Clauses 12 and 17 of the Bill, the Bill was read a second time.

THE ELECTRIC LIGHT AT JARROW.—The General Steam Navigation Company's steamboat "Albatross," since hired by the Government, has sustained an amount of damage to her keel, and likewise to the lower part of her stem. The owners arranged with a Jarrow firm to complete the repairs within seven or eight days, and Messrs. Clarke, Chapman, and Co., of Gateshead, were instructed to light up the dock where necessary with the electric light. On the following night workmen employed by that firm arrived at the yard with the necessary engine to produce the motive power, and with the lamps, which were of various descriptions. In less than three hours after arrival a current of electricity was forced through the wires attached to the lamps erected. The engine, which is very small, is one of the first of a new pattern at present in use, one of the others being in the possession of the Tyne General Navigation Company. It is scarcely necessary to say that the work for the Navigation Company could not have been done in this instance had it not been for the judicious use of the electric light.

FREEMASONRY.—On Thursday, the 6th inst., the R. W. Provincial Grand Master of Middlesex, Brother Sir Francis Burdett, Bart., P.G.W., consecrated the "Electric" Lodge, No. 2,087, at Hampton Court, of which Brother Edward B. Bright was designated the first master, Brother W. H. Preece Senior Warden, and Brother J. Hookey Junior Warden. The P.G.M. was supported by an influential gathering of members of the craft, among whom were Sir Charles T. Bright, P.D.G.M. Middlesex; Colonel Shadwell Clerke, Grand Secretary; the Deputy Provincial G. M. Dr. Ramsay, C. E. Spagnoletti, &c. The ceremony of constitution was very impressively conducted by the P.G.M., who congratulated the new lodge on having started under such favourable auspices. The Deputy P.G.M., Brother Raymond Thrupp, installed Brother Edward Bright as Master; and the following officers were appointed:—Wardens: W. H. Preece and J. Hookey. Treasurer: Major W. E. Williams. Secretary: George Gregory. Deacons: T. Barlow and H. C. Hart, I. G. T. Fletcher. Stewards: D. Lumsden and W. R. Culley. Three candidates were proposed for initiation and 21 as joining members. At the banquet which followed the usual loyal and masonic toasts were duly honoured. The meetings will take place on the fourth Saturday in May, June, and September, at the Mitre Hotel.

THE BOYDEN PREMIUM.—Uriah A. Boyden, Esq., of Boston, Mass., has deposited with the Franklin Institute the sum of 1,000dols., to be awarded as a premium to "any resident of North America who shall determine by experiment whether all rays of light, and other physical rays, are or are not transmitted with the same velocity." The following conditions have been established for the award of this premium: 1. Any resident of North America, or of the West India Islands, may be a competitor for the premium, the southern boundary of Mexico being considered as the southern limit of North America. 2. Each competitor must transmit to the secretary of the Franklin Institute a memoir, describing in detail the apparatus, the mode of experimenting, and the results; and all memoirs received by him before the 1st of January, 1886, will, as soon as possible after this date, be transmitted to the committee of judges. The board of managers of the Franklin Institute shall, before the 1st of January, 1886, select three citizens of the United States of competent scientific ability, to whom the memoir shall be referred; and the said judges shall examine the memoirs and report to the Franklin Institute whether, in their opinion, and, if so, which of their memoirs is worthy of the premium. And, on their report, the Franklin Institute shall decide whether the premium shall be awarded as recommended by the judges.

UNDERGROUND WIRES IN CHICAGO.—An American Contemporary says that this City is far ahead of New York in the work of removing the overhead telegraph nuisance, and it is likely that all the wires in the Garden City will soon be laid underground. The following figures approximate the miles of wire already placed beneath the streets of that city:—

Bankers' and Merchants' Telegraph Company...	400
Postal Telegraph Company	180
Chicago Telephone Company.....	28
Western Indiana Railroad Company.....	50
City Fire-Alarm Telegraph	60
Total.....	718

As soon as possible the Western Union Company will add 500 miles to this, and the Baltimore and Ohio Company 250 miles. This will make a grand total of 1,468 miles. Electric light wires are rigidly confined to buildings and personal premises, and the companies are forbidden to suspend their wires on poles or otherwise. The work of placing the fire alarm system under ground is being pushed as fast as possible. It is expected that it will take ten years to complete the work, and it will cost 500,000 dollars. Of this sum 50,000 dollars will be spent annually. The conduits are being constructed of a size and solidity which will insure their lasting. A mile and a half of these conduits have been completed so far.

THE TELEPHONE AT INVERNESS.—The district manager of the National Telephone Company at Inverness supplies us with the following particulars regarding the work of the past four

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months :—"It is scarcely four months since we began our exchange in Inverness, and to the list issued at that time (19th January, 1885), we have since added eleven new names, and are at present negotiating with the estates of Dochfour and Aldourie, and also for the establishing of a call office at Dochgarroch Locks, for the convenience of the steamer passengers and others resident in that district. By means of this office tourists may secure accommodation at the hotels they prefer, during the interval in which the steamer is going through the lock. The fee for speaking from Dochgarroch to Inverness will be the same as is at present charged in town, viz., 3d. for three minutes and 1d. for every minute additional. Since we opened we have taken an average of about 2,000 messages weekly, including 100 from call offices alone. That these call offices are being taken advantage of by the public there can be little doubt, as no less than 140 out of a total of 1,400 received have been paid for, representing an average of 10 per cent. There are at present about 60 subscribers in town, and each subscriber uses his telephone at least six times per day; thus, at the yearly rental of £10, the cost of each message is on an average about 1⅓d. This includes question and answer. It will also be of interest to know that the company have now over 60 instruments in operation and 26 miles of wire, there being a telephone to every 300 persons in Inverness."

Electrical Transmission of Power at Bienne, in Switzerland.—There are two turbines, one working at high pressure and the other at low pressure, placed at the village of Boujeon, at the falls of the River Suze. The high-pressure turbine has been in use for rather more than a year, to work a dynamo machine for the electrical transmission of power to two factories at Bienne. The total height of the fall is 177ft., and the quantity of water 330 gallons per second. The turbine, however, only utilises actually 157½ft. of the fall, and can take, when the guide blades are wide open, 88 gallons per second. The turbine is one of Girard's, with a horizontal axle, driving accumulator shaft by spur gearing. The generator is a Thury dynamo machine of the type H_2, compound wound, and is driven by a belt from the countershaft; it runs at a speed of 500 revolutions per minute, and gives an E.M.F. of 350 volts. The conductors consist of two copper wires 7mm. in diameter (about No. 2 B.W.G.), carried on telegraph posts and insulators. The motor is also a Thury machine of the H_2 type, compound wound. It runs at a speed of 400 revolutions per minute, with a difference of potential of about 300 volts at the terminals. The distance from the generator to the motor is about 1,367 yards, and the motor gives out from six to 18 horse-power, according to the exigencies of the work being done in the factories. Both ends of the line are protected by lightning conductors, a very necessary precaution in a district where thunderstorms are very prevalent. When starting the motor a resistance is at first switched into the circuit, but this is cut out by step as the machine starts. It is stated that a commercial efficiency of 70 per cent. has been obtained.

Pyro-electricity of the Topaz.—Friedel's observation that in topaz the principal axis of pyro-electricity is parallel with the edges of the prism has been confirmed. Many fragments show poles of the same sign at both ends, but in such cases the fragment can be cleaved into two parts, the bases of which will have opposite polarity. In one instance, one extremity of the fragment was bounded by the natural summit of the crystal, and the other extremity by a cleavage plane, and both ends showed negative electricity when cooled. When this fragment was cleaved at the middle, one half showed regular polarity, whilst the other half was still negative at both ends, but with different intensities. These results are explained by the existence of twinning parallel with the base of the prism. With colourless rounded Brazilian topaz the pyroelectricity was much less marked, and with certain sections was almost imperceptible. Frequently both terminations have the same sign, but in many cases the removal of a very thin layer changes the sign of one termination, and produces fragments with regular polarity. Optical examination shows that the topaz crystals are not homogeneous, but in many cases can be separated into four distinct portions along the diagonals of the rhombic base. Generally, however, these four parts enclose an inner rhombic prism with regular extinction, and the crystal can consequently be split up into five distinct portions, which, however, are still not homogeneous. From some larger crystals in which the planes of twinning were very distinct homogeneous fragments have been obtained, which establish the existence of a horizontal axis of electricity, but the specimens were not sufficiently large for the exact direction of this axis to be determined. The existence of the horizontal axis was confirmed by the development of electricity under pressure.

Determination of the Ohm by the Damping Method.—With some few exceptions, the various methods for the determination of the ohm which were brought before the Paris Conference all gave values of the ohm greater than 1·06 metre of mercury 1 square millimetre in section, except the damping method, which has always led to lower values. M. Mascart has been led to investigate more closely the theory of this method, in order to see if this difference may he accounted for. Without following his mathematical reasoning it may be said that Mascart arrives at a formula which is that given by Maxwell, viz. :—

$$R = \frac{M^2 G^2}{2K(\epsilon - \epsilon_0)}\left(1 + \frac{2L}{R}\epsilon\right)$$

where R is the resistance of the coil, M the moment of the magnet, G the mean galvanometer constant, K the moment of inertia of the magnet, L the coefficient of self-induction. When the damping is considerable the duration of the oscillations cannot be determined directly by experiment, and it is more general to deduce it from the relative duration, when the coil is an open circuit, by the formula

$$\epsilon^2 + \gamma^2 = \epsilon_0^2 = n_0^2$$

But this formula is not strictly correct; in fact, the correction which ought to be introduced into the calculation of the resistance, in order to take into account the coefficient of self-induction, is half that which is usually taken by adopting the above formula. This correction is, however, not the only one which has to be taken into account, but there is a more important one. In actual experiment the induced currents are necessarily very powerful, in order that the damping may be appreciable. These induced currents produce a temporary magnetism in the bar in a transverse direction, which must be taken into account. The intensity of the temporary magnetism of the bar is proportional to the action of the current. This magnetism does not modify the fundamental equation so far as the induction is concerned, but the earth's action on the bar introduces a new couple of opposite sign to that due to the permanent magnetism, and the value of this new couple must be subtracted. The original hypothesis as to the smallness of the deflections, and the constancy of the galvanometer coefficient G, may still leave some doubt as to the degree of exactitude of the result; but at any rate the two corrections referred to both tend to increase the values of the unit of resistance hitherto arrived at by the method of damping.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 491, Vol. XIV.)

Electrostatic Energy. Closed Displacement.

In the theory of electrostatics a tube of displacement has a beginning and an end, at its beginning there being positive, at its end negative electrification. The terminations of the tubes are usually upon conducting surfaces; there may, however, be interior electrification in the dielectric, if so, it has got there by convection, or by disruption. Impressed force in the dielectric is not considered in the theory of electrostatics. But should there be any, there will usually be closed tubes of displacement without electrification, as well as terminated tubes, due to the presence of conductors; and should there be no conductors, the displacement set up by impressed force is wholly solenoidal. This will be briefly considered later. At present we take the case of closed displacement in a dielectric arising from electromagnetic induction. Conductors are temporarily excluded for simplicity. Let there be any state of electric displacement D and magnetic induction B in an infinitely extended dielectric, without impressed forces. A possible state of induction and displacement is meant, of course. For instance, set up any state of displacement by impressed force, which then remove, leaving the system to itself. E and H being the electric and magnetic forces at any moment, we have

$$B = \mu H, \qquad D = cE/4\pi; \quad . \quad . \quad . \quad . \quad (66)$$

μ being the permeability and c the specific capacity. The tubes of B are always closed. Those of D are also closed, if there be no bodily electrification. We cannot, therefore, express the electrostatic energy in terms of the scalar electric potential and the electrification. The appropriate form is in terms of the magnetic current and its vector potential.

Let Z be such that

$$-\operatorname{curl} Z = cE, \quad . \quad . \quad . \quad . \quad . \quad . \quad (67)$$

which is possibly because this is the general integral of $\operatorname{div} cE = 0$, expressing that the displacement is closed. Z is the vector potential of the magnetic current. It is given by

$$-Z = \Sigma \frac{\operatorname{curl} cE}{4\pi r}, \text{ or } = -\operatorname{curl} \Sigma \frac{cE}{4\pi r}, \quad . \quad . \quad . \quad . \quad (68)$$

by potential properties. Here r is the distance from the point where Z is reckoned of the element of the quantity summed up through all space. To Z, as given by (68), any polar term may be added without affecting (67); Z, after (68), being wholly solenoidal, like B and D. Since the second equation of induction is

$$-\operatorname{curl} E = \mu \dot{H} = 4\pi G, \quad . \quad . \quad . \quad . \quad . \quad . \quad (69)$$

G being the magnetic current, the equation of Z, by (67) and (69), is

$$\operatorname{curl} c^{-1} \operatorname{curl} Z = 4\pi G; \quad . \quad . \quad . \quad . \quad . \quad . \quad (70)$$

from which we see that when c is constant, we have

$$Z = c \Sigma \frac{G}{r}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (71)$$

verifying that Z is the vector potential of the magnetic current.

If U be the electric energy (energy of electric displacement), we have

$$U = \tfrac{1}{2} \Sigma ED = \tfrac{1}{2} \Sigma \frac{D}{\operatorname{curl}} \operatorname{curl} E = \tfrac{1}{2} \Sigma ZG, \quad . \quad . \quad (72)$$

by potential properties, and (67) and (69).

These may be instructively compared with the corresponding magnetic equations. If A be Maxwell's vector potential of the electric current we have

$$\operatorname{curl} A = B = \mu H, \quad . \quad . \quad . \quad . \quad . \quad (67a)$$

resulting from integrating $\operatorname{div} B = 0$. And the first equation of induction is

$$\operatorname{curl} H = c\dot{E} = 4\pi \Gamma, \quad . \quad . \quad . \quad . \quad (69a)$$

Γ being the electric current. So, T being the magnetic energy, we have

$$T = \tfrac{1}{2} \Sigma HB/4\pi = \tfrac{1}{2} \Sigma \frac{B}{\operatorname{curl}} \operatorname{curl} H/4\pi = \tfrac{1}{2} \Sigma A\Gamma, \quad (72a)$$

by (67a) and (69a). And, if μ be constant, we have

$$A = \mu \Sigma \frac{\Gamma}{r}. \quad . \quad . \quad . \quad . \quad . \quad (71a)$$

These four equations marked a correspond to the former equations with the same numbers. We have also

$$E = -\dot{A} - \nabla P, \quad . \quad . \quad . \quad . \quad . \quad (73a)$$

and, to correspond thereto,

$$H = -\dot{Z} - \nabla \Omega, \quad . \quad . \quad . \quad . \quad . \quad (73)$$

P being the scalar single valued electric potential, and Ω the scalar single valued magnetic potential. (73a) is Maxwell's equation. To prove (73), we may merely remark that by (69a) the magnetic force round a closed curve equals 4π times the electric current through the curve; and by (67) the same relation holds between $-Z$ and 4π times the displacement. Or, differentiate (67) to the time, and compare with (69a).

So far as the energy expressions in (72) and (72a) go, it does not matter whether Ω and P are counted or not, though they usually exist, especially if there are variations of permeability or capacity from place to place.

Other forms of U and T:—When A and Z are wholly solenoidal,

$$U = \Sigma \dot{A} c \dot{A}/8\pi - \tfrac{1}{2} \Sigma P\sigma$$

$$T = \Sigma \dot{Z} \mu \dot{Z}/8\pi - \tfrac{1}{2} \Sigma \Omega \rho$$

if $-4\pi\rho = \operatorname{div} \mu\dot{Z}$ and $-4\pi\sigma = \operatorname{div} c\dot{A}$; (73) and (73$a$) holding good. Here σ is imaginary electrification, and ρ imaginary magnetic matter, the first being where c and the second where μ varies.

Simple Example of Closed Displacement.

In this example there is a conductor in the field, but as, from symmetry, it will be obvious that the displacement is wholly closed, it will not matter. If an intrinsic magnet be at rest in a dielectric, there is no electric force, but merely a state of magnetic force. But if it be set in motion there is immediately a field of electric force set up as well, and of displacement and electric current due to changing displacement. Whether the displacement does not or does cause electrification will depend upon whether it is, at the surface of a conductor, wholly tangential or not, for it is the normal component that introduces surface electrification. Now, if a straight bar magnet of circular section be carried through the air parallel to its length, the lines of electric force are clearly circles about the line of motion, so that the displacement in the air is wholly closed. Or, let a uniformly intrinsically magnetised sphere move through a dielectric in the direction of its axis of magnetisation with constant velocity v small compared with that of the propagation of light, so that we may regard the sphere's field of magnetic force to be rigidly attached to it and move with it without change. A certain state of electric force in circles about the line of motion, the continuation both ways of the sphere's axis, is set up, changing at any *fixed* point continuously. But if we travel through the air with the sphere, the electric field is stationary. We may thus regard the magnet as carrying with it, in rigid connection, a certain constant electric field as well as its magnetic field. The first approximation to the solution, by far the most important part, is readily found.

Let M be the magnetic moment of the sphere, of radius a; z distance measured along the line of motion, from a fixed origin, of the centre of the sphere at time t; r the distance of any point, P, from the centre of the sphere, and θ the angle r makes with z. The magnetic potential at P is

$$\Omega = M\cos\theta/r^2.$$

Let v be the velocity of the sphere, then

$$z = z_1 - vt,$$

t being the time and z_1 constant.

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This gives $d\Omega/dt = -vd\Omega/dz$;

so that the magnetic current at the point P is

$$G = \mu\dot{H}/4\pi = -\nabla\dot{\Omega}/4\pi = (v/4\pi)\nabla\frac{d\Omega}{dz};$$

or, using the above value of Ω,

$$G = (vM/4\pi)\nabla\{(1 - 3\cos^2\theta)/r^3\}, \quad . \quad . \quad . \quad (74)$$

the differentiation ∇ being conducted at P.

Calculate the total of G through the circle r, θ. This is, if $\omega = \cos\theta$,

$$\frac{vM}{4\pi}\int\int r^2 d\phi d\omega \frac{d}{dr}\frac{1 - 3\cos^2\theta}{r^3} = \frac{3vM}{2r^2}\omega(1 - \omega^2).$$

The circle r, θ is a line of electric force E. So, by the relation (69),

$$-2\pi r E\sin\theta = 6\pi v M\omega(1 - \omega^2)/r^2.$$

Or,

$$E = -\frac{3}{2}vM\sin 2\theta/r^3.$$

This could be got more simply, but we wanted an expression for G, and having it, made use of the relation (69) applied to a closed curve, or the Theorem of Version.

The last equation gives the strength of electric force at the point r, θ referred to the sphere's centre and axis of motion. The potential energy U of the displacement is

$$U = \Sigma cE^2/8\pi = \int\int\int \frac{c}{8\pi}\left(\frac{3vM}{r^3}\right)^2\omega^2(1 - \omega^2)r^2 dr d\omega d\phi$$

The limits for r are a and ∞; for ϕ, 0 and 2π; for ω, -1 and $+1$.

This gives

$$U = cv^2M^2/5a^3 = v^2M^2/5v_1^2a^3, \quad . \quad . \quad . \quad (76)$$

if v_1 is the velocity of light, the electromagnetic value of c being the reciprocal of v_1^2.

U is only a small fraction of T the magnetic energy of the sphere. This, by the formula $T = \Sigma\mu H^2/8\pi = \Sigma B^2/8\pi\mu$ is easily shown to be

$$T = 3M^2/a^3\mu(\mu + 2),$$

if μ be the permeability of the sphere, the outside value being unity. Thus, if $\mu = 1$ in the sphere also,

$$U/T = \tfrac{1}{5}v^2/v_1^2.$$

Travelling with the sphere, we have a steady electric field, and no current. But at a fixed point, the current, or rate of increase of displacement, is

$$c\dot{E}/4\pi = -(cv/4\pi)(dE/dz) = 3v^2M\sin\theta(1 - 3\cos^2\theta)/4\pi r^4 v_1^2.$$

As before remarked, the solution is the first approximation. In a complete theory there would be no discontinuity in the electric force at the surface of the magnet, as the above supposes, and there would be electric current in the magnet, with waste of energy by the Joule heating, thus requiring a continuously applied mechanical force to keep up the motion. Whilst, therefore, we should have disturbance inside the magnet, the solution outside would be not exactly that given. In fact, we see that the calculated dielectric current itself has its magnetic field, thus slightly altering the assumed magnetic field, that of the magnet at rest; and to the motion of this new magnetic field (very weak) there corresponds a new electric field, and so on. However insignificant these corrections may be in point of magnitude, they are yet required to make up a complete system satisfying the laws of induction. Taking, however, the above field of electric displacement by itself, we may close the magnetic currents in the appropriate manner on the surface of the magnet itself. The surface value of E is, by (75),

$$-\frac{3}{2}Mv\sin 2\theta/a^3, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (77)$$

and it is tangential. Hence the same expression divided by 4π, and taken positively, is, by the surface interpretation of (69), the strength of the complementary surface magnetic current, directed at right angles to the electric force—that is, along the meridional lines, if the poles be those points of the sphere cut by the line of motion through the centre. This system, with the former, makes a closed system of magnetic current, whose vector potential may be taken to be

$$Z = cMv\cos\theta/r^2, \text{ parallel to } z. \quad . \quad . \quad . \quad . \quad (78)$$

For this satisfies (67). This is literally the vector potential of a surface magnetic current of strength σv, parallel to z, σ being the surface density of free magnetism; but it is unnecessary to calculate the part due to the complementary current required to close it.

We can now check the value of U by the formula (72).

$$U = \tfrac{1}{2}\Sigma ZG = \tfrac{1}{2}\frac{3}{4\pi}\frac{Mv}{a^3}\frac{cMv}{a^2}\int\int\omega^2(1 - \omega^2)a^2 d\omega d\phi \quad . \quad . \quad (79)$$

Here we have to integrate the scalar product of Z and G through all space, Z being given by (78) and G by (74) outside the magnet, and by (77) (when divided by -4π) on its surface. But the volume integral outside the magnet vanishes, because Z contains Q_1 and G contains Q_3 as a factor (zonal harmonics). Hence there is simply the surface integral left, expressed by the right side of (79), the z component of the surface G alone counting. It gives the value (76) again.

The reason why (78) suffices for use in the formula $\frac{1}{2}\Sigma ZG = U$ is because G is completely closed. If, on the other hand, we employed the full formula for Z, we would not need to close G. A surface current σv parallel to z would then suffice. Thus, if $Z = Z_1 + Z_2$ and $G = G_1 + G_2$, wherein Z and G are both wholly closed, whilst the parts Z_2 and G_2 are polar, we have

$$\Sigma ZG = \Sigma(Z_1 + Z_2)G_1 = \Sigma Z_1(G_1 + G_2)$$

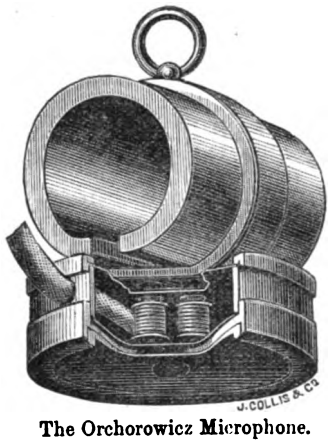
since

$$\Sigma ZG_2 = 0 \quad \text{and} \quad \Sigma Z_2 G = 0.$$

(To be continued.)

THE ORCHOROWICZ MICROPHONE.

A description of this powerful apparatus, the invention of Dr. Orchorowicz, will be found in *The Electrician* of February 21st and March 7th, of the present year. The system comprises, as will be seen from our illustration, a microphone



The Orchorowicz Microphone.

transmitter and a magnetic receiving telephone, the magnet of which is a steel cylinder, with a slot down the length of its surface about ¼in. in width, with two soft iron cores, three or four millimetres in diameter, arranged at the centre and carrying coils, which are enclosed in a case formed of two thin iron plates—one at the top opposite the cores in the usual manner, and the other at the bottom, the latter being screwed to the middle of the magnet. The lower plate is pierced with two holes of a larger diameter than the soft iron cores which traverse it, so as to ensure free movement; the two circular and parallel plates being connected together at their outer edges by a metal crown. In this way the two plates are only fixed by a point which connects the lower plate with the magnet, and form a vibrating box of great mobility.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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ANSWERS TO CORRESPONDENTS.

D. Q.—*From the inventor. Address is Schloss Fraunegg, Post Hausmannstetten b. Graz. Remember some experiments of your own in connection with this subject.*

A. E. F.—*Electrical tricyles have been invented by Prof. Ayrton, M. Trouvé, and others; but in cost and maintenance they are far from being economical.*

J. W. J.—*Advise you in your own interest to consult a patent agent.*

THE EXHIBITION RECORD

Was of necessity begun in the last number of Vol. XIV. We shall be happy, however, to present those of our readers whose subscriptions commence with the present volume with a copy of the Supplement gratis upon application.

THE PARLIAMENTARY COMMITTEE AND TELEPHONE WIRES.

The forebodings expressed in our last week's leading article as to the result of the Parliamentary inquiry on overhead telephone wires were, it appears, more than warranted by what we have learnt since then. Although we could not give credit to the statements which appeared in the *Standard* and *Daily News* of Tuesday last, it now appears that they were not far away from the actual truth, at all events as to the substantial verdict of the Committee. The Report is almost certainly not unanimous; but the majority have emphatically decided to declare in favour of the overhead wire system, and of conferring fresh powers on the Telephone Companies for the furtherance of their business.

We are not surprised at this result, for reasons which we gave last week, and for other reasons which anybody can discover for himself who casts his eye over the names of the men who sat on the Committee. Parliamentary inquiries are not conducted on the principles which prevail in less exalted spheres. Interested parties may sit and report judicially in the Committee Rooms at Westminster whose testimony, even as witnesses, would be accepted with reserve elsewhere. Another odd thing about this particular Committee is that, although the Telephone interests are fully represented upon it, the inhabitants of London and the Postal Telegraph Department—who are the only two other parties concerned—are but imperfectly represented, the latter, in fact, not at all.

Fortunately, a Parliamentary Committee is peculiar in one or two other respects. It is usually instituted to stave off legislation when inconvenient questions arise which Parliament does not want to legislate upon; and, better still, its decision has no legal force. It is one of the fictions of Parliamentary life, very expensive but absolutely worthless. The present publication, however, we fear, will be rather mischievous as well as dear. According to the *Standard's* account, the Committee have reversed on every point the Draft Report of its Chairman, showing that at least there was one man present who drew his conclusions from the evidence, and not from his breeches' pockets.

The Report, which will be found in another column, declares that the risk of danger from overhead wires has been greatly exaggerated. After this it admits that these wires should be better controlled and supervised than they are at present; and the Committee then recommend that "the erection of overhead wires should be continued." As to the "control and supervision," we may take this phrase as a mere sop to the enemy, for it is made perfectly clear that neither control nor supervision is to "hamper the extension" of the system. The Committee are also of opinion that telephone wires should be allowed to pass over property without the owner's or occupier's consent; and that where the owners or occupiers refuse permission to attach wires to their premises the "local authorities" should be empowered to override such refusal. As to the possibility of placing the wires underground, the Committee are as silent as if such a proposition had never come under their notice. This fact of itself stamps the whole Report as a one-sided deliverance.

That these recommendations are so preposterous is the most cheering feature about them, for they will certainly never take shape in a legislative enactment. Before that stage is reached we may confidently predict that our notions of what constitutes a public danger will take a more definite shape through the unceasing activity of the Telephone Companies themselves. Overhead swinging signboards have long been disallowed in the busy thoroughfares of the City. They never killed anybody that we heard of, but they were considered dangerous; and it is perfectly certain, if the local authorities had any jurisdiction in the matter, that overhead street wires and the ricketty erections which are supposed to hold them together, but which in reality are kept up by the wires, would be voted a public danger without a moment's hesitation. This most certainly would be the case if the occupiers of the premises over which the wires run were the owners of them; and the danger is not lessened, but rather increased, by their belonging to an irresponsible and powerful company.

As to conferring powers on the companies to attach their appliances to premises without the consent of the owners, we may dismiss it with the remark that fresh powers would be required to prevent the occupier attacking the appliances with axe and hammer without the consent of the companies. There are usually two parties to an occupancy, sometimes three—the ground landlord, the leaseholder, and the tenant—any one of

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whom could sue the other for b each of covenant if the Telephone invader is to have his way. But we may spare our arguments. An infringement of private rights so glaring would not be entertained, much less tolerated, by any legislative assembly in the world. The companies are posing themselves as public benefactors, and in that capacity hope to cajole Parliament into making extraordinary concessions; but the simple truth is that telephonic enterprise is a purely commercial affair, and that it is doing its work in the cheapest, flimsiest, and ugliest fashion in order to swell its dividends.

We do not blame the companies for this; but we do blame them for imagining that their attempted delusion will succeed, or that they can go on for ever on the principle they are working at present. Even their apparent triumph on this Parliamentary Committee would, if made a reality, prove disastrous to them. For, if Telephone Companies are to acquire exceptional rights, Electric Lighting Companies will claim them on equal terms, which could not be resisted. Yet, if Electric Lighting wires were carried in the beneficent—that is to say, cheapest—way the telephone wires have been carried, there would soon be an end to telephony. The two systems could not possibly live together; one of them would be rendered unworkable, and this one, we need hardly inform our readers, would not be the Electric Lighting.

OBITUARY.

It is with infinite regret that we learn the sad death of Mr. George Joseph Heraghty, the Superintendent of the Eastern and South African Telegraph Company's Station at Delagoa Bay, South Eastern Africa, which took place at Capetown on the 6th ultimo. Mr. Heraghty, who was in his 33rd year, was for many years in the service of the Eastern Telegraph Company at several of their principal stations, and on the coast line being opened in the commencement of 1880, left for Delagoa Bay, where he took a prominent part in the arrangement of the station buildings and the estate. As Relieving Superintendent he had successive charge of the Zanzibar and Mozambique Stations, besides the one to which he was finally appointed; and by his characteristic and unvarying generosity, his kindness and efficiency, won the affection and esteem of all who had the good fortune to come in contact with him. In Mr. Heraghty we cannot but feel that the company have lost an officer whom it will be difficult to replace, while many others, with ourselves, will deeply regret one who as a friend was beyond compare.

CORRESPONDENCE.

ELECTRICAL CONDITION v. RECENT SCIENCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Coxworthy's letter on the above subject encourages me to give an account of some hitherto unpublished experiments made by me several years since.

Referring to my notes I find that on 3rd July, 1877, while a heavy thunderstorm (as I then erroneously supposed) was taking place about five miles away, and rain falling heavily on the spot, I took a gold leaf electroscope to a small grass plot, and after placing it "on the grass" (to quote my note book), "again raised it six feet; the leaves now diverged a quarter of an inch." Two years later I arranged a quadrant electrometer in connection with an insulated water-dropper close to the grass plot mentioned above. The observations were recorded graphically. On 2nd April, 1879, my experiments came to an untimely end by reason of an enormous and sudden rise of potential. At 1:30 p.m. on that day the spot of light shot off the scale like greased lightning, and I found, to my dismay, that the mirror was smashed, and the needle jammed tight in the quadrants. By carefully measuring the force necessary to extricate the needle I was able to estimate the value of the potential. This amounted to no less than 632,501·206 volts!

What could have caused this truly awful potential? I must confess I was totally unable to account for it until on reading a sentence in Mr. Coxworthy's letter a complete explanation flashed on my mind. Mr. Coxworthy, on page 535 of your valuable journal, observes:—"I . . . then found that the potato-leaf absorbed the moisture, whilst the grass did not, but *without doubt evolved electricity*" (the italics are mine; indeed, I may say that on reading that pregnant sentence I nearly went into "italics" myself).

The enormous potential may, then, have been due to a blade or blades of wet grass being blown (as it easily might) against the water-dropper!

Unfortunately, Mr. Coxworthy does not give us any measurements of the amount of electricity developed on wet grass; but my experiment of 3rd July, 1877, detailed above, enables me to supply this omission. We see that the leaves are deflected ¼in. when the electroscope was 6ft. from the grass, the grass being very wet, as it was raining hard at the time. We have here all the data necessary for determining, with some approach to accuracy, the potential at the surface of the grass plot, due to an element, say one blade of grass; for, assuming the number of blades to be infinite, and remembering the law of inverse squares, an easy application of the calculus shows this potential to be approximately 632,503·155 volts.

The coincidence of this value with that previously obtained is too striking to be the result of mere accident, and must be admitted by all competent electricians to be a triumphant confirmation of the new theory which we owe to the genius of Mr. Franklin Coxworthy.—Yours, &c., S.E.

May 9th, 1885.

THE STEAM ENGINE INDICATOR.—VI.*

BY AMICE.

Assuming that we have sufficiently described and illustrated the modern steam engine indicator, and given a general idea of the nature and purpose of the indicator diagram, we may now proceed to consider the application and employment of the indicator and the use in particular of the diagrams obtained by it.

We have, then, first to attach the indicator to the steam engine cylinder. This must be done so that the supply of steam to the indicator is perfectly free—that is to say, so that the pressure in the cylinder is faithfully represented by that on the indicator piston. To effect this the passage from the cylinder must in no way be obstructed either by the use of connections with bore smaller than that of the indicator cock, and in all cases where a nipple, socket, or pipe is required they should be larger than this. No harm can be done by having such fittings or connections of from half-inch to three-quarter inch bore. When possible, the indicator cock should be screwed direct into the cylinder or the cylinder cover. All good engine cylinders are provided with a boss at the cylinder ends, or a local thickening of the cylinder flange, as shown at B, Fig. 28, the flange at other parts being as seen at Fig. 29. In these sketches A is part of a horizontal engine cylinder, C the cover, P the steam port, E the slightly enlarged end of the cylinder by which clearance is given to the piston, the latter just passing the edge E, and thus the whole of that part of the cylinder which is of the diameter of the piston is swept through, and wear does not leave a rim at the ends of the original diameter of the cylinder which may do harm, when, by fitting the connecting rod with new brasses, the piston is made to sweep over the rim left as the connecting rod is shortened up by wear of the old brasses. The boss B, then, is screwed with a three-quarter inch Whitworth thread, this being the size usually adopted for the indicator cock D, the upper part of which is internally coned to fit the cone at the end of the indicator cylinder, as already shown at, for instance, Fig. 21. The lower

* For Art. 5, see *The Electrician*, 3rd January, 1885.

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part of the hole in the boss B should be half an inch in diameter, and should be as near the end of the cylinder as possible, so that it is not covered by the steam engine piston, but at the same time it should be clear of the cover C.

Indicator diagrams should always be taken from both ends of a cylinder, as, although it may be supposed that the slide valve is accurately set, this is not necessarily the case. Moreover, the valve itself may not be properly proportioned, and the cut off and lead may alter with wear of the excentric and straps and the rod joint. There may be obstructions in one of the ports, the exhaust may not be so free from one end as the other, owing to misconstruction of the valve and the wear already mentioned. All these things would be found out by taking diagrams from both ends of the cylinder. For this purpose the boss (Figs. 28 and 29) should be made. When it

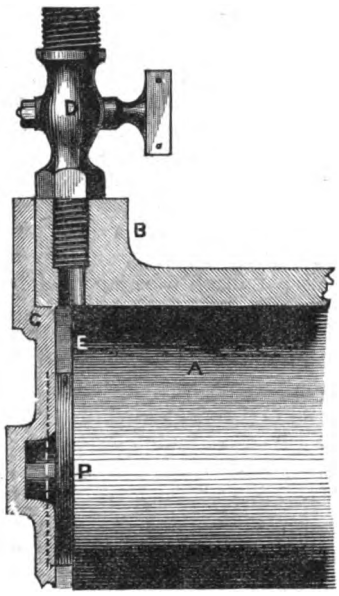

Fig. 28.

is desired to take diagrams at frequent intervals the two ends of the cylinder may be connected with a pipe, G, as shown at Fig. 29, which is one of several forms of such connections. A short piece, E, in the place of the cock shown at Fig 28, is screwed into the cylinder, the upper part of this being screwed

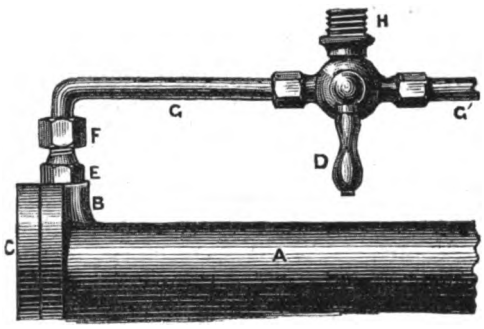

Fig. 29.

to take the union nut F, which is fitted to the end of the pipe G; the bend in the pipe should not be of small radius, although incorrectly shown with a short bend in the engraving, and should never be replaced by a right-angled elbow, as sudden bends have some effect on the flow of the steam, and may prevent the pressure in the indicator from instantaneously acquiring that which exists in the engine cylinder, and thus give an untrue rounded corner to the top of the steam end of the diagram. At D is a three way cock, C, by means of which the indicator is supported at H, and the steam admitted from either the one or the other end of the cylinder by the pipe G or G^1. The plug of the cock D should be made larger than would be sufficient for ordinary work, so that the hole through it should not only be large enough to pass steam freely, but so that the hole may be curved as shown at Fig. 30, which is a section of the three-way cock (Fig. 31) as made by the Crosby Steam-Gauge Valve Company for use with the Crosby indicator. It will be observed that the steam passes round an easy curve in this cock whether the plug be turned towards one or the other way. At one end of this cock is shown an expansion joint (Fig. 30), which for the temporary application of an indicator to different engines gives facility in connecting at and allows for expansion.

When this arrangement is adopted, the diagrams from both ends of the cylinder may be taken on the same cards as shown at Fig. 32, by simply turning the cock D, so that steam is alternately admitted from either end of the cylinder. This is of some advantage when diagrams have frequently to be taken, as the two diagrams are correctly placed in a comparative position, and a picture of what is going on during the strokes in both directions is obtained, from which a judgment of the working can be rapidly made.

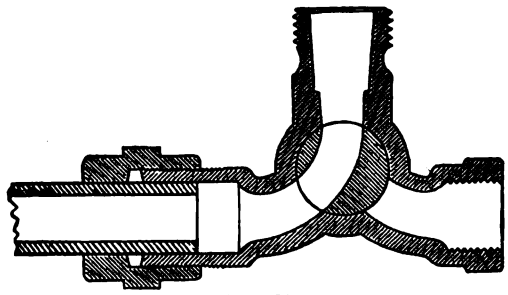

Fig. 30.

Where, however, only a few occasional diagrams have to be taken, and accurate measurements to be obtained from them, instead of simply obtaining a general diagnosis of the performance of the engine as far as the behaviour of the steam in

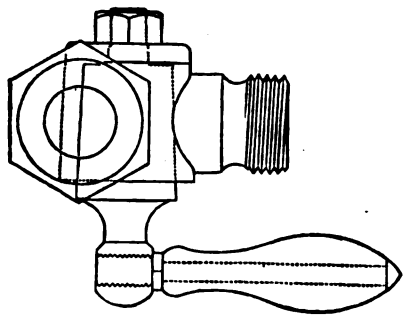

Fig. 31.

the cylinder is concerned, the separate diagrams are to be preferred. When large engines have to be indicated it is preferable that two indicators should be used rather than employing long pipe connections between the two ends of the cylinder.

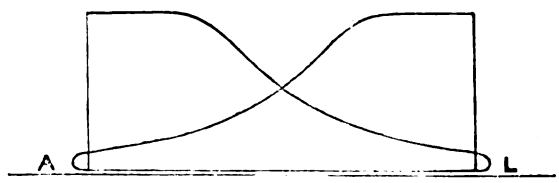

Fig. 32.

Steam in long pipes is likely to condense, and the presence of water in the pipes or in the indicator will destroy the truth of the diagram. The full pressure of the steam in the cylinder is not shown at the commencement of the stroke on the diagram, and the steam line is made irregular by the action of the water in pipe connections. In order to take two diagrams at nearly the same time, it is therefore necessary to employ an indicator at each end of the cylinder. For the purposes, however, of a general indication of the working of an engine on continuous work, as in flour mills, and its power, one indicator moved from time to time may be sufficient.

When vertical engines have to be indicated, an arrangement similar to that shown at Fig. 29 may be employed. This would hold the indicator in a horizontal position, which is in

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some respects undesirable, and may be avoided by having a bend fitted to the three-way cock, with a socket into which the indicator cock may be screwed. When this arrangement is not used, the indicator may be screwed direct into the top cylinder cover for the upper end of the cylinder, and for the lower end a pipe with bends must be used, so as to bring the indicator clear of the cylinder, and in a vertical position. The position for fixing must always be chosen with reference to the part of the engine from which motion is obtained for the indicator drum. When the pipe connections are not so attached that water may easily drain away from them, they should be provided with a small cock by which it may be allowed to escape. Provision for this should always be made. In all cases care should be taken that these connections are properly and firmly made and steam tight, and they should be strong, so that the indicator may be firmly held. It costs little more to do the work well, and diagrams upon which reliance may be placed cannot be obtained with the indicator hastily and badly applied with makeshift connections. If diagrams are wanted at all they should be accurate, and if it is worth taking them, it is worth taking them well.

REPORT OF THE OVERHEAD WIRES COMMITTEE.

The Select Committee appointed to consider the law relating to the control over telephone, telegraph, and other wires have agreed to the following Report :—

After careful consideration of the evidence, your Committee have come to the conclusion that the risk of danger to the public from overhead wires has been very greatly exaggerated.

The accidents which have been proved in evidence have been few and insignificant. In the most important instance the fatal result was due, not to the breaking of the telegraph wire, but to a well-meant attempt by a member of the public to replace it.

At the same time, your Committee are of opinion that the probable development of the telephonic system makes it desirable that there should be some change in the law relating to control over wires, with a view to their better supervision.

Regarding the free development and use of the telephonic system as essential to the public convenience, your Committee cannot recommend any course which would materially hamper its extension. The system of public telephone exchanges, whereby persons at considerable distances apart may converse freely the one with the other is a great public convenience. The number of subscribers to these exchanges is already over 12,000; the number of messages sent during the year was over 41,000,000; and the average cost per message was less than one penny. This system is daily growing, now that increased facilities have been given for the purpose by the Postmaster-General. In London alone the number of subscribers is nearly 4,000; but the capability of development may be estimated by the fact that, according to the evidence of Mr. Preece (electrician to the Post Office), there are more subscribers to the telephone system in New York and its neighbourhood than in the whole United Kingdom, notwithstanding that the charge in New York is about double what it is here. The annual number of messages in London is over 15,000,000.

The companies have recently proposed to place every post office in the London district upon their exchange system, upon any reasonable terms to which the Postmaster-General may agree, so as to afford the entire public of London the means of instantly conversing with subscribers to the system, and similar offers have been made by other companies for towns in their districts; and the Committee therefore recommend that the erection of overhead wires should be continued, subject to proper regulation and supervision.

Your Committee are of opinion that, under proper regulations, permission should be given to pass wires over property without the owners or occupiers having the right of prohibition; but this facility should confer upon those enjoying it no vested interest or easement, and should not relieve them from any claim for damage occasioned by them.

It was given in evidence that many of the inhabitants of the Inner Temple are desirous of being connected with the telephone exchange, but that the Telephone Company is unable to obtain permission to run wires for them. It was also given in evidence that a similar prohibition has been exercised in the case of Covent Garden.

Your Committee think that in special cases, where it could be proved to the satisfaction of the local authority on investigating the whole circumstances that certain individuals or certain districts were debarred from the public convenience of telephonic communication owing to such refusal, the local authority should be authorised to give permission to attach wires to premises under suitable regulations and on payment of such compensation as the local authority might think just.

Bye-laws for the regulation of all wires, as to substance, length of span, durability, and other matters, and for their identification and inspection, should be made for the whole of London by the Metropolitan Board of Works, for provincial towns by the corporation, for rural districts by the local authority, in each case subject to the sanction of the Board of Trade. In London the enforcement of these bye-laws should be entrusted to the Corporation of the City, and to the vestries and district boards.

ON THE SEAT OF THE ELECTROMOTIVE FORCES IN THE VOLTAIC CELL.*

BY PROFESSOR OLIVER J. LODGE, D.SC.

(Continued from page 517, Vol. XIV.)

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21. Experimental examination of three simple cells used like voltameters; and dependence of E.M.F. on current.
22. Summary of condensed statements embodying the writer's own views.
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24. Brief summary of the argument relating to the seat of E.M.F. in a pile.

19. Having now explained why I believe the main part of the Volta-effect to take its rise at the surface of contact between metal and medium rather than between metal and metal, it remains to consider whether this belief requires one to assert that there is no true contact-force at all at the junction of two metals. By no means: the existence of such a force is undoubted; but for metals it is usually very small and may be neglected in comparison with the Volta-force, though, strictly speaking, what is observed electroscopically is a mixture of the two. It is the true contact-force which gives rise to the Peltier effect, and its variation with temperature (assisted by the Thomson effect) causes thermo-electric currents. A contact-force exists, as Thomson has shown, not only at the junction of two different metals, but also between parts of the same metal at different temperatures.

In another place‡ I have endeavoured to gain some insight into the nature of this true contact-force and to suggest its cause. This has been done by many others; but I may be permitted to repeat my own notion, vague and incomplete though it avowedly is. Molecules of matter do not move in independence of electricity; at any rate the converse is certainly true—electricity does not move independently of matter. Electricity, in flowing through a wire, meets with resistance; there is something analogous to friction between the matter and the electricity, and the opposing force is precisely proportional to the strength of the current. This much is expressed by Ohm's law, $E = RC$, which is a carefully verified through empirical statement. But, analysing R into specific resistance of material (ρ) and sectional area of conductor, and permitting ourselves to regard $\frac{C}{\text{area}}$ as proportional to the velocity of electricity in a circuit of different thicknesses, we perceive that Ohm's law means that

$$\frac{dV}{dx} = \rho \times \text{velocity}.$$

* Reprinted from the *Phil. Mag.* for May.

† Very little of this chapter, and none of Chapter V., has yet been read anywhere.

‡ *Phil. Mag.* December (Supplement) 1876, "On a Mechanical Illustration of Thermoelectric Phenomena."

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Let us then postulate, between electricity and any given kind of conducting matter, a connection which shows itself as an E.M.F. proportional to the speed of their relative motion and to the specific resistance of the material. Molecules of matter are not at rest, but (say) vibrating at a rate depending on, or rather itself determining, the temperature. These motions, as we have seen, cannot be independent of electricity, but they result in no force urging it to flow, because their motions are symmetrical. But place two metals in contact—one hot, the other cold; or one copper, the other iron: at the junction symmetry disappears, there must be constraint and accommodation; and, in whatever precise way this acts, it seems probable that it can be conceived of as having the same effect as a layer of molecules moving faster on their outward journey than on their return. If any such dissymmetry of velocity were produced, it would exert a propelling force on electricity* in the direction of the greatest velocity, because the force is proportional to the velocity. This is the crude and tentative way in which I picture to myself the Seebeck or true contact-force—the cause of thermo-electricity and of the Peltier phenomenon.

But now, why is this force so small in ordinary metals? Because it depends on ρ, the specific resistance, and this is small. Choose badly conducting metals like bismuth and antimony, or still better selenium and tellurium, and the force will be greatly increased. Choose so-called nonconductors, like glass and silk and ebonite, and it becomes enormous. But when one uses nonconductors we cannot expect to excite currents flowing in closed circuits; we can only expect electrical displacement and electrostatic phenomena; and indeed it is no such easy matter for electricity to move in such substances, even though the force urging it be excessive; and a little mechanical violence (friction) may be necessary to help it to move. But remember that no amount of friction can determine the motion in one direction rather than another; working a pump-piston exhausts no air unless there are valves. Friction may supply some of the energy, but the directing force must be in the substances in contact†. To assist the passage it is customary in electrical machines to touch together a conductor and insulator rather than two insulators. I doubt not that when metal touches glass the surface of contact would become chilled as soon as any transfer of electricity were really produced by the force; but the heat developed, by the friction apparently necessary to aid the transfer, effectually masks any chilling.

Measurement of contact force between insulators is beset with difficulties, because it is so difficult to make electricity pass across the junction. No limit to the force has at present been observed: whenever an electrical machine reaches its limit, and refuses to charge its prime conductor or a Leyden jar to a higher potential, it is accounted for by saying that the rate of leakage is now equal to the rate of production (which is undeniably true), but nothing is said about whether the rate of production is the same as it was when the jar was uncharged. It is a difficult matter to settle, because most of the leakage takes place close to the rubber; and, though it is quite possible, it is unlikely that a limit to the force will be discovered, by finding the activity of a frictional machine less at high potentials than at low. When the substances in contact are two metals, it is impossible for them to drive electricity very hard, for it would, so to speak, slip through their fingers; but when an insulator is concerned, its grip is so great that probably there is no limit to the force until its insulating power is overcome, and through it also electricity begins to slip. Certainly any upper limit must be a very high one, for the force can readily pile up a charge till it produces sparks a foot or more long.

Whether *Volta* forces, or contact-forces between substances and the medium surrounding them, exist for insulators also we do not know; we have no reason whatever to deny their existence; but whereas in the case of metals these exceeded the forces acting between the substances themselves, here in the case of insulators they are absolutely negligible by comparison. For intermediate substances they may have correspondingly important values; and it seems not unlikely that at the junction of metals with electrolytes, and of electrolytes with one another, the total contact-force may be a complex one—partly chemical, and due to the possibilities of chemical action straining across the junction, and partly physical, due to different velocity of the molecules.

20. The preliminary experiments of Bouty have caused him to believe in the existence of physical contact-forces, at the junction of metals with electrolytes, which cannot be brought into harmony with energies of chemical action. And though the subject is too unexplored in this direction to be ripe for discussion, it may be well to point out that these contact-forces are important in the theory of the voltaic cell even in its simplest form.

Why is the E.M.F. of a zinc-copper battery less than that of a zinc-platinum?

Why is the E.M.F. of a zinc-lead or iron battery smaller than either?

The chemical action goes on in each, zinc is dissolved at one end and hydrogen liberated at the other: how, then, can the E.M.F. be different if it is calculable from the chemical reactions?‡

If we picture to ourselves the actual forces in action we shall get a kind of answer indicated to us. In a zinc-iron cell the E.M.F. is due to the zinc pulling at oxygen harder than the iron does; but, since the iron does pull too, with no inconsiderable strength, the balance of force is not so great as if the iron were replaced by copper, which pulls less, or by platinum, which barely pulls at all until it is coated and alloyed with hydrogen.

This answer cannot be considered as complete, and in order to complete it consider a more precise experiment.

Arrange a series of common dilute acid voltameters, with their plates respectively, zinc zinc, zinc iron, zinc copper, and zinc platinum. Pass one current through the series, from zinc to the other metal, and measure the differences of potential between the plates in each cell. Now the same chemical action is going on in each. In each zinc is dissolved at one side and hydrogen evolved at the other—the only difference being that it is liberated from surfaces of zinc, iron, copper, platinum, in the four cases. What is to prevent the E.M.F. between the terminals of each voltameter from being the same? But it is not the same (*pace* Prof. Exner): the zinc-zinc cell shows the greatest difference of potential between its terminals, the zinc-iron less; and the zinc-platinum may easily show a reverse difference because it helps the current on instead of hindering it. It will be understood that the *precise* behaviour of the cells is determined by the intensity of the current (*i.e.*, current per area)—if it is weak, even the zinc-iron cell may help it on, but the zinc-platinum will help it on most: if it is very strong, even the zinc-platinum will retard it, but the others will retard it more, and the zinc-zinc most.

Now, why is all this? Take the difference between the heats of formation of Zn,SO_4 and of H_2, SO_4, at the comma, and you will have the total energy assimilated by the current in each cell. This energy is the same in all the cells, but not in all does it take the same form. In the zinc-platinum cell it mainly results in driving the current forward. In the zinc-zinc cell it wholly results in a Peltier (or Bouty) generation of heat. In going out of the cell by a cathode zinc plate, it has to move hydrogen towards it, and (*ipso facto*) oxygen away from it, in opposition to the strong chemical attraction; thus it will do work and liberate energy, which, since there is nothing better to do, must exhibit itself as heat. At an iron surface less heat is generated, and at a copper less still; but, at any cathode which attracts oxygen, some heat must be generated by a current made to do work in opposition to this attraction.

In the zinc-zinc cell there is no propulsion of electricity at all by the cell; on one side, where the current enters, zinc is dissolved and the current helped forward with the full energy (or nearly the full energy) of the combination, so that no (or nearly no) waste energy or heat is there produced; but on the other side, where the current leaves, the same combination is (not exactly undone but) opposed and the current hindered with (probably something less than) the full energy of the combination, and there the heat of combination is generated.

Thus, regarding the passage of hydrogen to the cathode as a virtual separation of O (or SO_4) from it, we may say in general that in any one of the above cells used as a volta-meter, the energy available for helping the current on is that represented by the difference between the combination energies of the substances respectively attacked and liberated; *i.e.*, $Zn, SO_4 - H_2, SO_4$; but that besides this, the combination M, SO_4 is virtually undone; and, since the energy of this combination appears as a generation of heat at the cathode, it is so much to be subtracted from the propelling force available for the current, only the balance being leit for this purpose, viz.,

$$Zn, SO_4 - H_2, SO_4 - M, SO_4.$$

Whether one ought to write SO_4 or O in these expressions I am not sure, but it is not essential to decide this at present.

Another way of regarding the matter is to say that the force propelling the current is that due to the difference of energies Zn, O—M, O, but that as soon as a current actually passes and hydrogen is libereted it coats the cathode more or less thickly, and an extra term must be subtracted from the above to represent the opposition force of this hydrogen. The efficacy of this hydrogen as a current-opposer must depend in some way on the intensity of the current itself, since with the feeble current it will be able to dissipate itself faster than it forms, and with a strong current it will thoroughly coat the plate and the balance will escape. Suppose, then, we represent the force exerted by the hydrogen as $H_2O\,f(C)$; where $f(0) = 0$, and $f(\infty) = 1$ or something like 1; then the force available for urging the current forward in any of the above cells is, in volts,

$$\tfrac{1}{40000}\{Zn,O - M,O - H_2,O\,f(C)\}.$$

There is an obvious objection to be taken to this last hypothesis, viz. that it supposes the second metal M completely operative, even though it be thoroughly coated with hydrogen. This is hardly reasonable; and a compromise between the two preceding hypotheses is afforded by one of greater generality in which the available force is symbolically represented by

$$Zn - M\,\phi(C) - H_2 f(C),$$

where ϕ is a function such perhaps that $\phi(C) = 1 \div n.f(C)$.

On this hypothesis the propelling E.M.F. is

$$e = \tfrac{1}{40000}\{Zn, O - M, O - (H_2, O + n\,.\,M, O)\,f(C)\}.$$

* I do not say necessarily on *positive* electricity. It seems a complication; but Sir William's researches show that it is positive in some metals and negative in others. In the case of lead only does the grip on both electricities seem the same.

† Mr. Joseph Thomson (*Proc.* Roy. Soc. 1876) endeavoured to extend ordinary contact methods to non-conductors. He was hardly likely to get very clear results; but he was able to find some electrical transfer as the result of mere contact, if it be admitted that it is possible to apply mere contact and no sort or kind of violence—a supposition which is probably inadmissible. Yet the least violence destroys all novelty, and sends us back to Thales.

‡ Professor Exner cuts this knot in characteristic fashion by asserting roundly that the E.M.F. of all such cells is the same, and that it matters not hing what metal is opposed to the zinc of a cell so long as it does not alter the chemical action going on. He further asserts that all batteries are non-polarisable and quite constant, as soon as they have got rid of dissolved air and before sulphate of zinc has accumulated. He verifies these extraordinary statements, to three significant figures, by straightforward experiment. See his paper "On Inconstant Voltaic Batteries," cited above.

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This is too much like miscellaneous guessing, and we will make no more of such hypotheses ; but if experiment could fix an empirical formula for this force in any case, we could apparently at once obtain the Joule or Bouty effect,* or rather the difference of two such effects, for that case ; because we should have the E.M.F. experimentally observed on the one hand, and that calculated from pure energy considerations on the other, as

$$\frac{Zn, O - H_2, O}{46000} + B_M - B_Z,$$

where the two B's stand for the Bouty coefficients at the zinc and the other metal respectively. The only objection is that in the cells now under discussion M is coated more or less with hydrogen, and hence the Bouty effect obtained is nothing very easily definable.

(To be continued.)

PHILADELPHIA EXHIBITION.

(Continued from page 380, Vol. XIV.)

The National Underground Electric Company of New Jersey.

("C." of the Section's Classification.)

This conduit consists of a number of metal tubes imbedded in a kind of insulating pitch, formed in a suitable trough. At the corner of each street there is a water-tight manhole for hauling in or out wires as required. Provision is also made for tapping wires for house-to-house supply. This forms the subject of a separate patent. It is proposed to place telephone, telegraph, and electric light wires in different tubes, so that they shall not interfere with one another. The metallic lining of the ducts, it is claimed, will pass off readily any induced currents which may be generated. The moisture or damp can be kept out by forcing dry air through one or more of the tubes or conduits from a fixed plane along the line.

The company state that the cost of the conduit per mile will be $8,300. A mile of conduit has been laid under Market-street, Philadelphia. The committee were unable to examine its condition, as it contains no wires at present.

Hendley's Conduit for Underground Lines.

("A. b." of the Section's Classification.)

This system consists of a semi-cylindrical trough or conduit for the reception of the conductors, with a suitable cover of any desired configuration, angular shaped being preferred, as by its removal, when necessary, the wires and their supports are more thoroughly exposed. Below the trough and integral therewith is a drain pipe of suitable diameter, for carrying off all moisture that may finds its way into the conduit by condensation, exudation, or leakage. A narrow slot extending throughout the length of the trough opens therefrom into the drain pipe, the curved sides of the former rendering it almost impossible for any heavy particles of moisture to remain therein. This slot serves also to sustain the bolts which pass through the shoe to which the standard of the wire supports are secured, thus rendering it easy to place the supports at such intervals as may be desired along the conduit. This structure, with the supporting arms is really "a telegraph underground." Modifications of these slotted arms have been suggested which it is thought would, in practice, make this feature thoroughly effective.

Testing chambers are placed at such suitable points along the line as may be necessary, and in these provision is made to test, tighten, and otherwise manipulate the wires. A full description of this feature of the system cannot be fully set forth herein. At one side of the conduit brackets are secured, and from these rods extend, over which travellers having suitable pulleys in their interior which move on the rods, pass and carry the wires from manhole to manhole ; cords are attached to each side of a traveller, and pass thence to reels secured near the surface of the earth. These manholes can be placed at frequent intervals along the line, by securing wires to a suitable clamp at the bottom of the traveller, and they may be run in at any point simply by reeling in the cord.

Pipes for inducing currents of air are led into chimney stacks, the heat of which is made available for that purpose, or they may pass into the open upper air, and currents of hot or cold dry air may be forced into the conduit by means of fan blowers. Both devices may be used, though either separately would be effective, for carrying off all the lighter particles of moisture, and thereby keeping the conduit thoroughly dry and at a uniform temperature all the year round, and thus rendering, it is thought, a thorough insulation of the conductors unnecessary. Provision may be made by this system for a future increase in the number of conductors to be employed without having to tear up the streets, so that when once the system is built it remains a permanent and available plant, adapted not only to present but to future use.

Comments by Examiners.

This conduit consists of a semi-cylindrical trough of iron, terra cotta, or, preferably, of glass, fitted with an angular-shaped cover. At the bottom of the conduit there is a pipe connected to it by a slot for the purposes of drainage, and for fixing a standard with recessed and insulated arms for carrying the wires.

Manholes are provided at suitable points, and also small pipes for house-to-house supply.

* That is the thermo-electric contact-force at a metal-liquid junction ; see section 6.

Provision is made for either ventilating the conduit by induced currents of air, or of forcing hot or cold air through it in order to expel all moisture. No provision is made for induction in telephone wires. The standards carrying the wires are secured to the conduit by one bolt each, and it would seem difficult, without continual inspection, to keep them in position.

Magner's Underground Conduit.

("A. b." of the Section's Classification.)

This system consists of a conduit constructed of cast iron, terra cotta, &c., having a longitudinal slot A' at its top, for the introduction of wires or cables. This slot is bevelled and made tight by bolts and clamps bearing on the inside of the conduit. The joint is further secured by suitable packing.

The wires or cables are supported on insulated rollers, which revolve freely on a series of horizontal shafts, suitably supported and arranged one over the other. These rollers may be formed in one piece, or may consist of a number of independent rollers separated by washers. The distance apart of the rollers, both horizontally and vertically, is such as to prevent contact between the wires or cables when strained up.

The inventor claims that his system provides a conduit applicable to all descriptions of wire or cable, which is easy of access for the insertion or removal of any wire or cable, and in which the wires are kept taut.

The inventor did not submit any plan for manholes, or any arrangement for providing house-to-house supply, nor does he claim any method of obviating the efforts of induction. He proposes to lay down well insulated wires, as the conduit would be necessarily more or less damp.

After the conduit has been laid and filled with wire, any alteration to the system would require that the street should be opened from end to end.

Philadelphia and Seaboard Telegraph and Cable Company.

("A. a." of the Section's Classification.)

The material used in constructing this conduit consists of hemlock wood, copper wire, various compounds and insulations, the nature of which the inventor did not disclose.

The wood is exposed to a solution for several hours, at the temperature of boiling water. The composition being easily distributed through the mass of soft wood, incrusts the cells with a compound which makes the wood absolutely moisture and decay proof. The carpenters now take the wood (which has become dry and hard) and make a hollow box—the core of the conduit—which is filled in with insulated telephone wires, arranged according to a plan not disclosed. When the core is filled, insulating material is again poured upon the wires, filling in the interstices, making a dry solid mass. The top is now cemented on. The finished core now receives a second coating of the waterproof compound. Around this core are now built the receptacles for the insulated telegraph conductors. There are two inches of insulating impermeable compound between the telephone and telegraph circuits, 6in. between all sides, ½in. all round.

The finished core is now set in the outer shell of the conduit, which is also made of the prepared wood 1in. thick. A moistening compound is now run in around the core and the top covered with a plank of the same prepared wood, pressing into the compound, making two inches of solid impermeable matter between the core and the casing, three inches between the core and the earth, five inches between the telephone and the earth. The sections are all prepared at the factory before being taken on the ground. They are run into sleeves every 20ft. Twenty loops are run out on each side of the sleeve and covered with a waterproof cap, so that the wires are at all times accessible. The wires are connected through the sleeve with a patent, hard paper, double connector.

The electric light conduit is made in a similar manner, but the wires are widely separated, and different materials are used in insulating and fire waterproofing.

The advantages claimed for this system are :—(1) It is fireproof ; (2) it is waterproof, it will not decay ; (3) it is a perfect insulator ; (4) no leakage between telephone and telegraph wires ; (5) the arrangement of the conductors in the lanes to divert induction, &c. ; (6) the wires will not corrode ; (7) the wires cannot break, no pulling of cables through tubes, no abrading, no strain ; (8) insulated wires can be tapped and conveyed into each dwelling without disturbing the main conduit ; (9) it is cheaper than a pole line.

	Price per mile.
100 Telephone wires, delivered on ground	$2,500
1,000 Telephone wires, delivered on ground	$9,750
100 Telegraph wires, delivered on ground	$2,750
1,000 Telegraph wires, delivered on ground	$12,750

Comments by the Examiners.

The whole success of this system would depend on the nature of the insulating material and the chemical preparation of the wood, &c. Without trial, over an extended period of time, it would not be possible to test this conduit for endurance and the other points claimed by the inventor.

The Union Electric Underground Company of Chicago.

("A.a." of the Section's Classification.)

This conduit consists of a tube 10in. in diameter of kalamine (a mixture of lead and tin), which is said to resist the chemical action to which all underground conduits are subjected—on each side of this main small tubes of the same metal 2in. in diameter. The large tube is designed to accom-

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modate the main wires and the small tubes those which run short distances ; and at regular intervals there are joints by which house-to-house connection can be made. Instead of the wires being covered with an insulating coat, from which they cannot be withdrawn, they run through a tiny pipe, a little smaller than the familiar macaroni tube, and this pipe is manufactured independently of the copper wire. When this pipe has been tested the copper wire is forced into it by an ingenious machine. Should the copper wire at any time need repairing the same machine withdraws it from the well-fitting covering and then replaces it.

The inventor claims that this tiny tube is the best insulator known. It is made of vulcanised rubber, three sixteenths of an inch being its thickness, and one-sixteenth of an inch being the diameter of the opening. The rubber is covered with a thick electric deposition of copper. The deposition surrounds the tube and is said to prevent induction by carrying the surplus electricity into the ground.

By the tube system each wire can be removed without the others, with which it is bunched, being disturbed in any way The electric light wire which, on account of the great insulation, can be handled with perfect safety when the strongest current of electricity is running on it, costs less than $500 a mile, or half the usual cost, and takes up about half the space that an electric light wire usually occupies.

The inventor claims that by the use of his special insulation he can run all descriptions of wire in one tube.

The conduit can be laid for $8,000 a mile. The main tube will hold 1,700 wires, and the side tubes 50 each.

The insulation was found to be very brittle, and it would be difficult to bend it out of the manholes and tapping tubes without injury. The wires must be necessarily very expensive, not only to manufacture, but to force into their insulated tubes afterwards.

WOODWARD'S CURB CONDUIT.—SYSTEM B.

("A. b." of the Section's Clasification.)

In the accompanying engraving, Fig. 1 is a perspective view of the combined curbstone and conduit, showing the wires in position ; in the second figure the wires and cover are removed. The hollow curb conduit sections, A, made of cast iron or other suitable material, are formed with

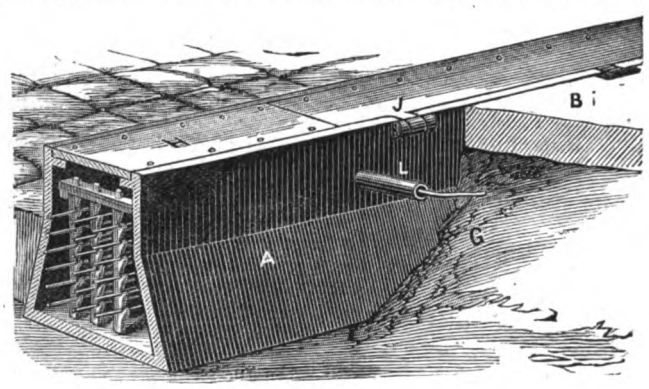

FIG. 1.

vertical sides above the street pavement to form the curb, and those portions sunk in the ground are widened out at the bottom to guard against displacement and provide ample space. The cover J is about flush with the sidewalk. Between the cover and the top of the ledges is placed a water-tight packing. The wires are supported by a series of vertical racks, E, fixed at suitable intervals apart. The lower ends of the racks enter sockets in the bottom of the conduit, while their upper ends pass through holes in cross stays, D, the extremities of which rest in brackets on the sides. The ends of the conduit section are flanged and bolted together, packing being inserted between them.

When it is necessary to provide for longitudinal expansion and contraction of the several sections, they are made with overlapping ends, and are secured by bolts passing through slots in one of the flanges. Packing is placed between the joints. The wires are inserted from the open top of the conduit and rest in the teeth of the racks ; after they are in position the cover is bolted down. When it is desired to conduct one or more wires into a building, small lateral pipes, L, are connected to the side of the conduit. With this construction the wires are always easily accessible and the tearing up of the pavement in order to reach particular points is obviated. The two-plan views show clearly the methods of rounding corners. When the conduit crosses the street where the curb ends, those wires which are above the line of the depressed part are directed downward, and kept in place by means of tranverse studs.

The advantages claimed for this system are: That it is easier and cheaper to place the wires in the curb than to tear up the streets and put them in an underground conduit.

That owing to the curb conduit widening and deepening from the level of the paved street it gives ample room for holding any number of wires.

That to introduce into a house any telegraph, telephone, or electric light wires, by merely removing a few bricks from his pavement, the connection is made direct with the curb conduit, instead of excavating many feet of earth in the pavement and the street by the underground conduit.

That it is always accessible.

If anything happens to a wire, or a new one is to be introduced, one can always get to it in the curb conduit, and during the snow and ice of winter, when the authorities of cities will not allow the streets to be opened, the curb conduit is as accessible as in the warm months of summer.

Comments by the Examiners.

In this system no provision is made for keeping the conduit free from moisture, so that a first class insulation is required for the wires or cables used. Further, no method is proposed for obviating the efforts of induction in telephone circuits.

To obtain the advantages claimed for it, a conduit must be run on both sides of the street in order to give house-to-house supply.

It would further appear that a long line of iron plate along the side walk would be dangerous to foot passengers in frosty weather, and would interfere with present arrangement of gas lamps and the existing sub-pavement and street cellars.

No estimate of cost was given. The system would necessarily be an expensive one.

(To be continued.)

COMPANIES' MEETINGS & REPORTS.

London Platino-Brazilian Telegraph Company (Limited).

The seventh ordinary general meeting of the shareholders of this Company was held at the offices, No. 66, Old Broad-street, on the 11th inst., under the presidency of John Pender, Esq., M.P.

The SECRETARY (Mr. William Payton) having read the notice convening the meeting and the minutes of the last meeting, the report of the Directors was taken as read.

The CHAIRMAN : In the remarks I have to make I must draw your attention first to the fact that there has been an increase in the receipts over the land lines in Uruguay. The amount was £2,646 in 1883, and in 1884 it was £3,271, showing an increase of £625 over the preceding year's receipts. Since I last had the pleasure of addressing you we have been paid the debt which the Government of Uruguay had been owing to us for a very considerable time—a debt which at one period we were not over sanguine about. Thanks, however, to Senor Lanza, who has been very persistent with, but, at the same time, very conciliatory towards, the Government, that debt, which stood at £7,360, has been paid off, but it was paid off in bonds at par. As you may observe from the accounts, their realisation shows a loss of £2,937. I may say that that is a settlement much in the same way as other debts have been arranged, and I think that on the whole we have rather reason to congratulate ourselves on having been paid. The Government accounts have been paid to the end of January, and we have urged our agent to see that the Government pay their messages' account in future with regularity. I am glad to find that our agent is on very friendly terms with the Government, who, as we all know, is not very rich or flush of money ; but they appreciate the mode in which we are doing our work, and consequently they are the more disposed to pay accounts, the non-payment of which they know would eventually embarrass them, because without a return on our land system we are not likely to maintain it in the efficient state in which it ought to be maintained. Our agent writes to us, "The President of the Republic, to whom, from the first alarm of the invasion, I offered without limit the use of the lines, has stated that he is very much satisfied with the rapidity and exactitude with which the telegraph service of this Company has been carried out, and also with the willingness of the clerks." I may mention that through the issue of the *pronunciamiento* a considerable amount of telegraphing was caused on the part of the Government ; and since this matter has been settled, more or less, trade has resumed, and we are therefore doing a very fair business at the present time. With regard to the cable receipts, there is a falling off. The revenue in 1883 was £12,638, while for the past year (1884) it was £10,655, a difference of nearly £2,000—a sum sufficient to pay another half per cent. dividend. Our dividend last year was 2 per cent., whereas this year it is only 1½ per cent., but we carry over a tangible sum—£1,046—available for reserve for the equalisation of dividend in future, or otherwise, as occasion may warrant. Some portion of the decrease is attributable to an interruption of the cable of the Brazilian Submarine Company for more than three weeks in March, 1884 ; but it is mainly owing to the reduction of the tariff over the Western and Brazilian Company's cables. It is satisfactory to know that the earnings of that company, in which we are so much interested, show a considerable increase since the 1st of January last over the corresponding period of 1884 ; but this improvement will appear in next year's accounts. As to the difference between the Western and Brazilian Company and this Company I may mention that the negotiations are still going on. They have been very prolonged ; but there have been many causes which have interfered with a settlement being brought about. In the first place there have been negotiations going on between the Western and Brazilian and the Brazilian Submarine Companies, which I am afraid have not come to anything like a satisfactory settlement. On the other hand, the Western and Brazilian Company have been attempting to make some arrangements with the Brazilian Government, who, I am sorry to say, are not acting in that spirit which they promised they would show when submarine telegraphy was first introduced on their shores. I mentioned, I think, when I addressed you last year, that in the early days of submarine telegraphy the Emperor of Brazil himself expressed the opinion that, while his country could not give the Company money by way of subsidy, they would give every possible facility in their power to

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encourage the submarine cable system. The Government, acting behind him, I am afraid, have the power, and they are not acting up to the promises and the spirit of the statements made by the Emperor. What the result may be it is very difficult for me to say, but I hope that the Government of Brazil will find, in dealing with the submarine cable system, which has enormously benefited their territory, that unless they treat its proprietors in that liberal spirit which we consider we are entitled to, and in that honest spirit in which they are bound, as a Government, to act, the result will not be advantagous to them, and that they will find, in short, that after all "honesty is the best policy." Our negotiations with the Western and Brazilian Company are still going on, and I believe they have now advanced to the point of being in the hands of the respective solicitors. We may shortly hear the result of these negotiations, and before we take any step in completing them, I believe we are bound to put the whole case before our shareholders, and after that a special meeting will, if necessary, be called to give them full information as to what the bargain is. I think, gentlemen, that these remarks embrace pretty well all that I have to state, and I therefore beg to move: "That the report and accounts for the year ended March 31, 1885, submitted to this meeting be and they are hereby received and adopted, and that a dividend of 1s. 9d. per share be declared, payable this day, free of income tax."

Mr. JOHN HOLLOCOMBE seconded the motion.

The CHAIRMAN invited discussion, and expressed his readiness to answer, to the best of his ability, any question which might be asked of him. No shareholder, however, rising to speak, the resolution was put and carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. HOLLOCOMBE, Mr. Francis Pavy was re-elected to his seat at the Board, and subsequently on the motion of Mr. W. FORD, Messrs. Deloitte, Dever, Griffiths, and Co. were reappointed auditors.

Mr. FORD then proposed a vote of thanks to the Chairman and Directors for the way in which they had managed the affairs of the Company in the past year.

The resolution was seconded and carried unanimously; and, in reply,

The CHAIRMAN said: Gentlemen, I beg to thank you on behalf of my co-Directors and myself. I only wish that the concern were larger, and that I could offer you a greater dividend; but we are in a comparatively helpless state, because we are entirely dependent on the management of another concern for the dividend we pay you. Therefore, as I have already stated—and I repeat it now—I hope some satisfactory arrangements will be come to whereby this Company will be absorbed by a larger company—in short, I should not object to see the whole of the telegraphs on that coast under one system. I think the result would probably be—if proper financial arrangements could be made, to suit all parties—that not only would the shareholders be benefited but the public generally. I believe that "union is strength," and, as far as I am concerned—and I believe those associated with me take the same view—when the time comes when a general amalgamation should take place, you will not find us dissentients.

The proceedings then terminated.

Submarine Cables Trust.

The fourteenth ordinary annual meeting of the certificate holders in the Submarine Cables Trust was held at the Offices, No. 66, Old Broad-street, on the 12th inst., John Pender, Esq., M.P., in the chair.

The SECRETARY (Mr. Lewis Wells) having read the notice calling the meeting and the minutes of the last meeting, the report of the Trustees was taken as read.

The CHAIRMAN: Before I put the usual resolution I desire to make one or two remarks as to what has been done during the past year. The accounts now presented are made up in the usual form, giving the fullest information as to the position of the Trust. The amount which the Trust had to deal with last year as dividends on their investments, including the amount brought forward, was £24,449; and the expenses were £1,324. The payment of the coupons absorbed £20,289; in purchasing nine certificates £886 was spent; and we carry forward £1,950. With this balance and the dividend on the Eastern Extension Company's shares it is anticipated that we shall be able in the current year, in spite of the diminished dividends from the Anglo-American Company, to pay the coupons in full, and leave a small balance over. The Atlantic cable competition is a very serious matter. The present tariff is not one which can be regarded as remunerative. The last dividend received by us, a few days ago, from the Anglo-American Company, was only £490, against £1,544 in the corresponding quarter of 1884. This competition at the present moment is not likely to lead to higher dividends; the chances are, I am sorry to say, for a time, that they are very likely to lead to lower. The present tariff is not remunerative in any degree, even to the new company who have just established their line. The Mackay-Bennett Company must have been carried on at a very serious loss by the transfer of their money, which had been previously invested in American securities, into this system. As far as I can see, if they keep their accounts as they ought to, they cannot show much over 2½ per cent. That to them, with a new cable, and having all the advantages of modern science and lower costs, places them in a satisfactory position as far as competition is concerned. On the other hand, the Anglo-American Company and the other companies have a certain goodwill of the business, and if it comes to competition I have no doubt they will be able to do their business well and efficiently. At the same time, this will not bring the money, and what I look forward to by and bye is that it will be urged, in the interest of the shareholders, that some rearrangement of the present tariff should take place. When that is done this Trust Company will participate in the advantage which will accrue. Fortunately, however, there are other companies in which we hold a considerable interest who are doing decidedly better than they were; and the consequence is that what we lose by the Anglo-American Company we make up by the others. I therefore think we may rather congratulate ourselves that, by reason of the moneys we have in hand, we shall not have to default in the coupons. Almost one fifth of the capital of the Trust has been redeemed, and the market price of the certificates is about par, or 10 per cent. above the price of issue. We are entirely dependent on the income we receive from other companies, but, as a whole, our investments are such as to enable us to keep on paying our coupons in full, and I am very hopeful that before the year advances much further there will be some arrangement by which the Atlantic system will give a better dividend than it does at present. In that case we shall be benefited. I now move "That the report and accounts of the Trustees now submitted to the meeting be approved and adopted."

Sir DANIEL GOOCH, Bart., M.P., seconded the motion.

A SHAREHOLDER inquired whether there was much increase in the business in the Atlantic Companies.

The CHAIRMAN: I am sorry to say that the amount taken over all the systems is considerably less than last year.

The SHAREHOLDER said he had meant to ask if there was an increase of messages to any extent.

The CHAIRMAN: No, if there had been an increase of messages there would be an increase of revenue.

The SHAREHOLDER: The cheap rates do not increase the traffic?

The CHAIRMAN: No. When the Mackay-Bennett Company opened their system at 1s. 8d. a word against 2s., which was the rate previously charged, they caused a clear loss of £150,000, which you might just as well have thrown into the sea. The difference is so infinitesimal upon the amount of telegraphing that is passing that neither the sender nor the shareholder receives any benefit. I am hopeful that common sense will prevail eventually, and that we shall have a tariff established that will give a fair return to those who have put their money into Atlantic telegraphy.

The resolution was then put and carried unanimously.

On the motion of Mr. K. ANDERSON, Mr. John G. Griffiths and Mr. John Gane were re-elected auditors for the current year.

A vote of thanks was afterwards passed to the Chairman and Directors.

The CHAIRMAN: I am very much obliged to you, gentlemen, on behalf of my colleagues and myself. We are watching your interests and what the other companies are doing, and I hope when we meet next year we shall be able to tell you that there are better prospects for the Atlantic cables than I can show at the present time.

The proceedings then terminated.

Great Northern Telegraph Company of Copenhagen.

Abridged report of the annual general meeting, held at Copenhagen on the 25th April, 1885, F. Zahle, Esq., presiding.

The CHAIRMAN (C. F. Tietgen, Esq.) addressed the meeting with regard to the working year of 1884, by first of all referring to the cables owned by the Company. The state of the same had been so to say normal; there had been the ordinary rather numerous cases of interruptions, but in no instance had these sensibly affected the Company's receipts. Amongst these interruptions one, however, deserved to be specially referred to, viz., a breakage which occurred in one of the cables in the Gulf of Bothnia, on the 13th December last. Thanks to the precautionary measure taken in 1883, when a third cable was laid across the gulf, as explained at the last general meeting of the Company, this interruption had caused no inconvenience, and they had been enabled to postpone the repairs of the same until the more propitious spring season. The shareholders would have observed from the monthly traffic returns which had from time to time been published, and from the profit and loss account which had been laid before them, that the net revenue had been larger than in 1883. This increase had not been due to the receipts on the Company's European lines, on which, on the contrary, there had been a diminution of traffic owing to the general stagnation of trade, but was exclusively attributable to the increase in the receipts derived from the Company's lines in the Far East. The receipts from the latter might have been considerably larger had it not been for certain stipulations contained in the French and Chinese concessions, in accordance with which some classes of Government messages, of which there had been a great number during the year owing to the war, had to be transmitted free of charge. Notwithstanding, or, perhaps, owing to, the political disturbances in China, the development of the inland telegraph system in that country had been actively progressing. The land line connecting Hankow, the great commercial centre in China, with the general inland system, had been completed, and after several intermediate stations had successively been established, the station at Hankow was opened for traffic on the 15th June last. On the 22nd August the first telegraph station had been opened at Peking, and no doubt the establishment of the telegraph in the capital had contributed largely towards the acceleration of the final peace negotiations between China and France. A new line had also been constructed in the north of China, connecting Newchwang and the new Chinese naval establishment at Port Arthur (Port Li). In the south of China a line had been constructed from Canton to the Tonkin frontier, and branching off to the important island of Hainan. As all these and other Chinese land lines could in a great measure be considered as feeding lines for the Company's cables, the Company had so far hailed their establishment with great satisfaction, although it had not from the very beginning been overlooked that the development of the Chinese land line system might sooner or later also prove competitive as regarded the Company's cable routes. A land line had, in fact, last year been opened between Foochow and Canton

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as a continuation of the Chinese Shanghai-Foochow line, thus creating a competition with the Company's Shanghai-Amoy-Hong Kong local traffic. It was, however, confidently believed that the general development of the telegraph correspondence would not fail to counterbalance any threatening influence of some competitive land lines, and hitherto the financial results had not given rise to any serious apprehension. The telegraph field which the large commercial ports on the coast of China offer is so vast that there would be room enough for both cables and land lines. Meanwhile the Company had not lost sight of the fact that by the concession granted on the 8th June, 1881, the Chinese Government guaranteed the Company against such competition, and naturally the Company had immediately, when the same arose, remonstrated against the breach of this obligation. Up till now, however, only evasive answers had been received from the Chinese authorities, who appeared to meet certain difficulties in carrying out the engagements entered into by the Government. Considering that latterly grave political matters have engrossed the attention of the Chinese, it had not been deemed opportune at this present moment to press for an immediate favourable decision with regard to the Company's legitimate rights. In order, however, that the moderation thus shown by the Company should not be misunderstood, due notice of the infraction had been given, and in order to reserve their rights the Company had, fully agreeing in this measure with the Eastern Extension Telegraph Company, provisionally stopped the free transmission of the Chinese Government telegrams. Thus the matter stood at present, but the Company trusted that, when the political horizon in China had been cleared, the moment would arrive when the Government would find means to conciliate their own interests with the undoubted rights of the Company. Meanwhile, the Company were in possession of the opinion on this point of both eminent statesmen and legal authorities well versed not only in international law, but also well acquainted with Chinese institutions and customs, which opinions assured the Company of the perfect legality, even from a Chinese point of view, of their claims under the concession granted in 1881. With regard to other matters, the Chairman would only mention that the exchange of the old share warrants against new ones, referred to last year, had now been effected, and apparently to the satisfaction of everybody concerned. Also that the capital of the pension fund for the staff had been separately invested, and would therefore in future not figure in the balance-sheet. From the balance-sheet, which had already been placed before the shareholders, it would appear that after all the general charges, as well as the ordinary charges for interest and amortisation of debentures, and the payment of the usual 5 per cent. interim dividend during the past year had been provided for, there remained an amount of £135,504. 11s. 9d., which the Directors submitted to the meeting to deal with as follows:—£45,833. 6s. 8d. to be divided amongst the shareholders as an extra dividend of 3 per cent. (making the dividend for the year, including the interims already paid, 8 per cent.); £2,777. 15s. 7d. to be allotted to the pension fund for the staff; £55,555. 11s. 1d. to be added to the reserve and renewal fund; and £31,337. 18s. 5d. to be carried forward to next year's account. It was with much regret that the Chairman had to announce that the Company had again suffered a great loss by the death of two members of the Board of Directors, Mr. Julius Sick and Mr. Moritz G. Melchior. The former had been a member of the Board from the formation of the Company, and the latter joined the Board in 1874. Both had, by taking great interest in the Company, contributed considerably towards its ultimate success, and he was convinced that the shareholders would much regret their loss. To fill up the vacancies which had thus occurred, the Directors had asked C. St. A. Bille, Esq., late Minister for Denmark in the United States, and M. Melchior, Esq., to join the Board.

Without discussion the report was then unanimously adopted, the accounts were passed, and discharge given to the Board of Directors.

The retiring Director, the Chairman, C. F. Tietjen, Esq., was unanimously re-elected. The election of C. St. A. Bille, Esq., and M. Melchior, Esq., as members of the Board, was also unanimously confirmed; and A. Berner, Esq., and Aug. Garde, Esq., were re-elected as shareholders' auditors.

The West India and Panama Telegraph Company (Limited).

Report of the Directors, to be presented at the sixteenth ordinary general meeting of members:—

The Directors submit the accounts for the six months ending 31st December, 1884. The amount to credit of revenue is £40,983. 2s. 6d., and the expenses have been £26,047. 19s. 8d., leaving a balance of £14,935. 2s. 10d., which, with the balance of £3,933. 18s. brought from last account, makes a total of £18,869 0s. 10d. Of this sum the Directors have placed £8,000 to reserve, leaving an available balance of £10,869. 0s. 10d., with which it is proposed to deal as follows:—Payment of 6s. per share on account of arrears of dividend on the first preference shares £10,368. 18s.; balance to current half-year's account, £500. 2s. 10d. Total, £10,869. 0s. 10d. The traffic receipts show an increase of £535. 16s. 4d. over those of the corresponding period of last year. The Directors have much satisfaction in announcing that their long-continued efforts to effect the complete restoration of the original cable between Jamaica and Porto Rico have been successful—this important work having been accomplished on the 24th October last by the Company's ss. "Grappler. The line (700 knots in length) has since continued in good working order. By the re-establishment of this cable (which had been inoperative since 1874) the duplication of the most important section of the system is restored, and the colonies eastward of Jamaica have already realised the advantages of the duplication during two interruptions which have occurred since the repair was effected. The value of the cable expended during the half year on this restoration amounts to £6,917. 15s. 8d., which has been charged to the reserve account. The expenditure from first to last involved in the restoration amounts in the aggregate to £33,657, and this heavy outlay constitutes a further claim on the colonies which have not increased their subsidies beyond the original sums granted many years ago. At the time those grants were accepted it was contemplated both by the colonies and the Company that a single line of cables would secure the communication, which subsequent experience has proved to be a misapprehension. The colonies of Barbadoes, Guadeloupe, and Martinique have renewed their subsidies for further terms of years. The Company's appeal for a renewal of the St. Thomas subsidy, which expired on the 31st December last, is now under the consideration of the authorities of that colony. Several interruption to the cables occurred during the half year under report, and the Company's ships have been frequently employed in repairing operations. Since the repair of the Jamaica-Porto Rico cable, the ss. "Grappler" has been chiefly engaged in the examination of the original (duplicated) cable between Jamaica and Santiago de Cuba which has long been inoperative, but much difficulty has been experienced in the operations from time to time owing to the great depth of water and rocky ground. The ship is at present engaged on other repairs, but will return to this work when at liberty. The Company's second repairing ss., "Duchess of Marlborough," will shortly come to England to be refitted. On her return to the West Indies she will take out a further supply of new deep sea cable for repairing purposes. In accordance with the Articles of Association, Charles William Earle, Esq., and William Ford, Esq., retire at this meeting, and offer themselves for re-election. John George Griffiths, Esq., the auditor, also retires and offers himself for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. May 13.		Business Done Week Ending May 13. Highest.		Lowest.	
Anglo-American	27,	28	27½		27¼	
Do. Preferred	47,	48	48		47½	
Do. Deferred	6¼,	6¾	6½		—	
Brazilian Submarine	10⅜,	10⅝	10 13-16		10½	
Cuba	10¼,	10⅝	10⅝		—	
Do. Preference	17,	18	—		—	
Direct Spanish	1½,	2	—		—	
Do. Preference	10,	11	—		—	
Direct United States Cable	8½,	9	9½		8¼	x.d.
Eastern Telegraph	11⅛,	11⅜	11¼		10 15-16	
Do. 6 per Cent. Preference	13¼,	13½	13⅜		13¼	
Do. 5 per Cent. Debentures, 1899	105,	108	—		—	
Eastern Extension	12⅛,	12⅜	12 5-16		12	
German Union	9¼,	9½	—		—	
Globe Telegraph and Trust	6⅝,	6¾	6 13-16		6 9-16	
Do. Preference	12⅝,	12¾	12½		12⅜	
Great Northern	13⅛,	13⅜	13⅛		13¼	x.d.
Indo-European	31,	32	—		—	
Reuter's	7½,	7¾	—		—	x.d.
Submarine	175,	185	182		180	
West India and Panama	⅝,	¾	13-16		⅝	
Do. 1st Preference	7½,	7¾	7⅝		—	
Western Brazilian	5⅝,	5⅞	5 7-16		5⅜	
Western Union 7 per Cent. 1st Mortgage	117,	122	—		—	
Do. 6 per Cent. Sterling Bonds	100,	103	—		—	

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	½	7-16		—	
Oriental	⅛,	⅜	¼		—	
United Telephone	11½,	12	12⅛		10½	

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1,	1½	1⅝		1 1-16	
Do. (fully paid)	2⅞,	3¼	3		—	
Hammond Light (£3 15s. paid)	⅛,	⅜	⅜		¼	
Swan	¼,	½	—		—	
Maxim-Weston	⅛,	¼	3-16		—	

MISCELLANEOUS.

Telegraph Construction	34,	35	35		34½	
India Rubber, Gutta Percha, and Telegraph Works	21,	22	21½		21½	

TRAFFIC RECEIPTS FOR APRIL, 1885.

Companies.	April, 1885.	April, 1884.	Increase.	Decrease.
Brazilian Submarine	—	—	—	—
Cuba Submarine	3,700	3,410	299	—
Direct Spanish Telegraph	1,510	1,811	—	301
Direct United States	—	—	—	—
Eastern Extension	41,233	37,044	4,189	—
Eastern Telegraph	63,085	51,975	11,110	—
Great Northern	24,800	—	—	—
Submarine	—	—	—	—
West Coast of America	4,215	—	—	—
Western and Brazilian	—	—	—	—

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THE INTERNATIONAL INVENTIONS EXHIBITION.

The progress made at the Exhibition during the past week has been very slow. The spurt put on to have an appearance of readiness at the opening ceremony seems to have used up all the energies of the exhibitors, and stands are still empty, or scantily furnished. Our criticisms upon this state of backwardness were a day or two since met very satisfactorily by one of our most energetic business men, whose firm is a large exhibitor. The answer to the state of unreadiness was so complete that we give it without compunction. "It is easy," says our authority, "to furnish a stand from articles in stock; but, as a rule, these are well known articles, and the Exhibition is intended for novelties. My exhibit is historically complete, because this portion was to hand, and needed little or no thought; but the novelties are not, and cannot in the nature of things be guaranteed to be ready to a day or a week. A machine of novel construction may have been completed weeks or months ago, but on trial found to require alterations here and there. This work of alteration takes time, and the satisfactory completion of an improved machine cannot be made to agree with a fixed date. We desire to send specimens of our latest and most improved machines," says the speaker, "machines which bear the stamp of 1885, and not those of previous years."

This desire, and consequently the backwardness, in many cases is allowable; but there are numbers of exhibitors who cannot be classed in the category of "exhibitors of novel machines." They are, and will be, merely advertisers of standard wares, examples of which could have been put together for exhibition any month within the last year; and yet their stands are empty. Deep, if not loud, rumours have reached us, though not with sufficient definitivness to enable us to speak positively, that some of the difficulties in the way of exhibitors have been caused by the absolute incapacity of certain members of the official staff. So far as the electrical exhibits are concerned, we shall be glad to receive any facts for or against official action, not necessarily for publication, but rather that the weak points of the system may be brought to light, placed before the proper authorities, and remedied. It must not be forgotten that even now the organisation of the 1886 Exhibition is under consideration, and if it is shown to absolute certainty that any members of the staff are incapable or inefficient they can and must be removed. Enough, however, of such rumours; let us proceed to facts. The electric light apparatus is still in such a chaotic state that we prefer the quieter walk through the East Arcade, where the electrical exhibits are supposed to exist. Entering from the vestibule we notice that Messrs. Crompton and Co. have a complete historic exhibition, showing the development of the several branches of their manufacture. This exhibit will be treated fully and illustrated in due course when complete, for the latest development has to come.

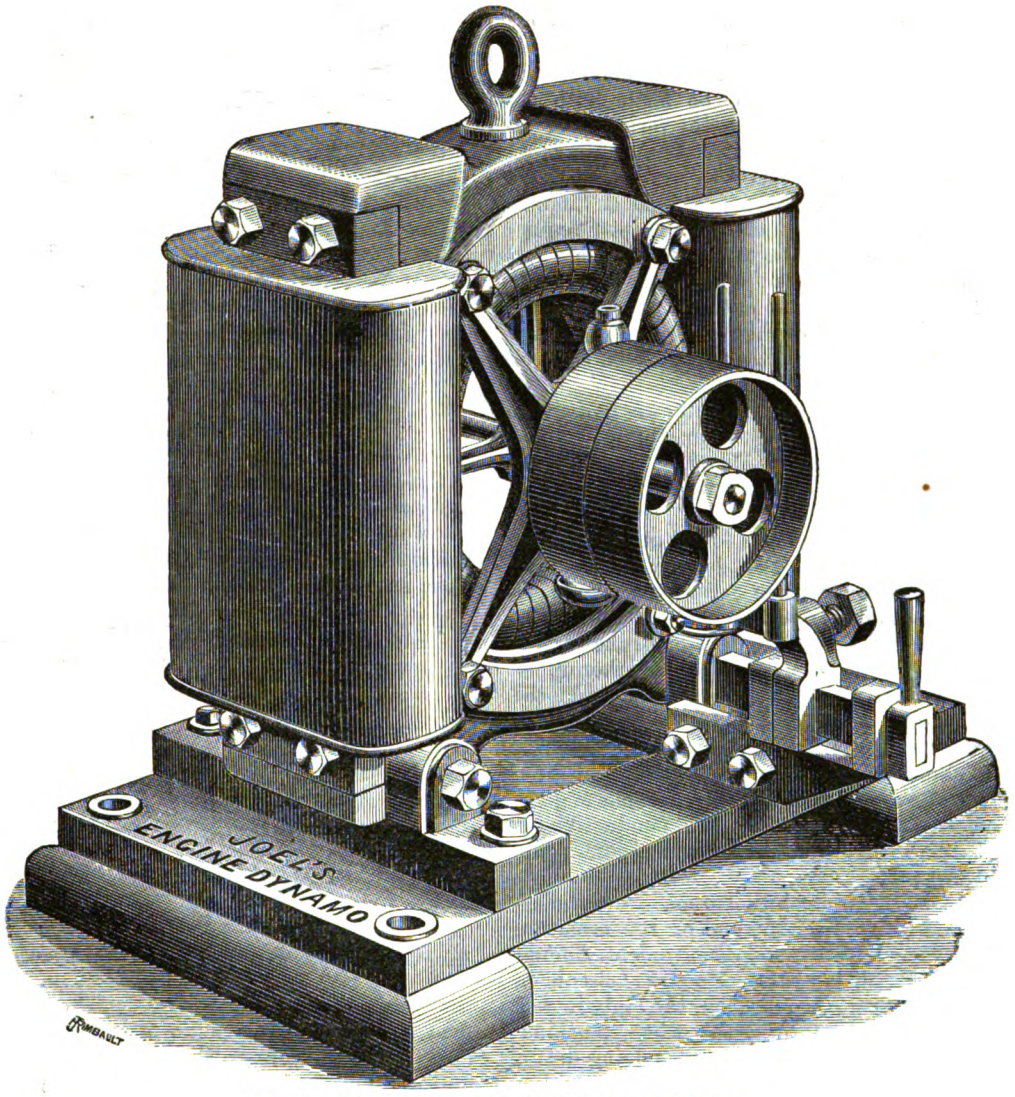

FIG. 1.—Joel's Combined Engine Dynamo and Motor.

Opposite to Messrs. Crompton's is a Crossley Otto gas engine, partially erected, and a stand which is also partially erected. Further on we come to the exhibits of Messrs. Woodhouse and Rawson, whose stand is perhaps the most complete in this part of the building. Messrs. Woodhouse and Rawson show

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specimens of their numerous manufactures. A variety of incandescent lamps for various purposes are among the exhibits, some of the ordinary type for ordinary lighting, others with silvered backs for reflecting the light in given directions; others, and smaller lamps for surgical instruments and to apply to microscopes.

We have often referred to these lamps, and gradually the lapse of time allows us to have a better idea of the economy than can be obtained from theoretic reasoning. As is well known to our readers, Messrs. Woodhouse and Rawson claim that their lamps are very economical, but the question which has had to be decided, or rather which has to be decided—sufficient time has not yet elapsed to decide it—is that of the life of the lamps of great economy of current. From theoretic reasoning it can easily be seen that almost any given economy of current can be obtained, but we have long held that there must be a mean position between economy of current and length of life. That will ultimately be found, and it will be approached by all makers, so as to give an economical lamp. There is no doubt that, if the makers ultimately find a high-resistant lamp can be made with the same length of life as a low-resistant lamp, the former will be adopted, inasmuch as it would be an economical user of current. Besides the lamps, we have upon this stand a variety of minor appliances used for electric lighting purposes, such as holders, cut-outs, switches, terminals, &c. Some of these will require illustration, and will be referred to again. On the left and right again we come to almost vacant spaces, till the right-hand corner is reached, where some excellent specimens of Mather and Platt's workmanship are shown in the Edison and Swan United Company's exhibits of Edison-Hopkinson dynamo machines.

Coming now into the Arcade, on the left we notice the exhibits of H. F. Joel, who, among other things, shows, perhaps, the largest cell of a secondary battery that has yet been constructed; also his new dynamo, which, however, is not running.

Mr. Joel claims that the disadvantages found in other forms of electrical storage batteries have been overcome, and that this battery, the outcome of over three years' special experiments and trials, is thoroughly practical and reliable. The advantages claimed for it are :—The construction of the battery is mechanically efficient; the plates are clamped together under pressure, they cannot buckle or get out of shape, and the deploraising material cannot get out of place; the electrodes are independent of the outer case, and when not required for a length of time are easily taken out and thus preserved from local action; the special formation of the electrode plates gives them great storage capacity, and good electrical conductivity.

We are indebted to Mr. Joel for the following description of his dynamo :—

In most of the dynamo machines hitherto made the mechanical construction of the whole machine, and of the armature in particular, has been very defective and inconvenient. Should an armature become deranged, say through a short circuit in one of the coils, or from the ring slipping on the hub, it was impossible to repair it without returning the whole machine, or at least the armature, to the maker, thus involving delay, and for a time rendering the apparatus useless, and bringing the whole system into discredit. It was to remedy this defective mechanical construction that this dynamo was designed. During the last six years many experimental magnets and dynamo machines have been made, and many improvements introduced, the result being the dynamo machine here described.

The general construction of the machine is readily seen from the illustration Fig. 1. There are two vertical field magnets with very massive cores made of wrought iron, carefully chosen and annealed; these are bridged across at the top and bottom by heavy iron poles, moulded in selected cast iron. This form is considered to give the best magnetic field. It is a great point in this machine that there is plenty of iron of good quality in its construction, and the iron is so disposed that there is very little waste weight. The under faces of the poles have slots or grooves cast in them to break up eddy currents, and to accentuate the magnetic effect as much as possible at the centre of the poles. The coils are wound on a bobbin or sleeve, and can be easily taken off. Fig. 2 shows the complete armature, which is of the Pacinotti type; it is built up of sections or groups of laminated iron plates of segmental shape, which are punched or stamped with the tooth-shaped projection alternatively at one end out

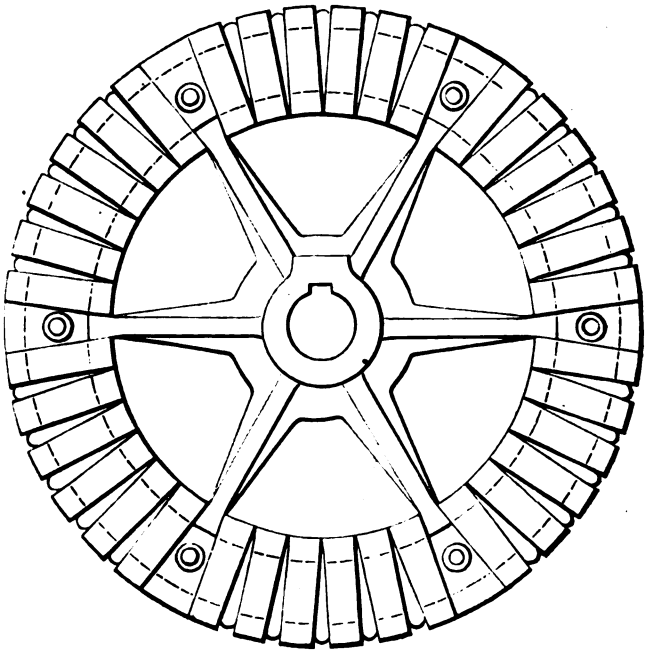

FIG. 2.—Diagram of Built-up Armature.

of the best Swedish iron (see Fig. 3). These thin plates are insulated from each other, except at the junction of the sections, where iron is pressed in contact with iron to form a series of continuous rings. The complete sections interlock and fit each other, and are fastened by bolts (also insulated) to the end of

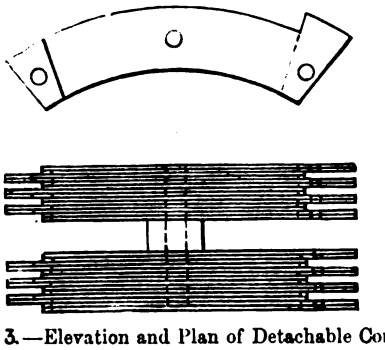

FIG. 3.—Elevation and Plan of Detachable Core Section.

spokes made of non-magnetic material, and thus form the rim of a wheel armature. With this construction the armature cannot slip or get out of place; it is rigidly fixed, not merely clamped as in some machines. The bolts are fixed parallel to the axle to prevent their loosening by centrifugal action. The

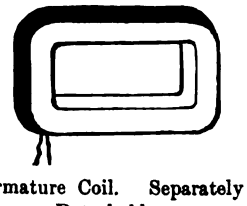

FIG. 4.—Armature Coil. Separately Wound Detachable.

insulated wire coils (see Fig. 4) are separately wound in a lathe or otherwise—this is a special feature of the invention—and are then threaded on the core sections. Should a coil become damaged the core section is taken out, and the coil slipped off and a new one quickly put in its place. The com-

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mutator is fixed close to the armature, and the ends of the coils are connected in a special and convenient manner to the commutator; and, in order to facilitate the removal of any of the coils on the armature, they can be quickly connected or disconnected without soldering.

The brushes are supported on an adjustable frame, which is fitted on the end of the axle; the unscrewing of one milled hand nut allows the brushes and holder to be taken off, and the same nut clamps the brushes in any position. The movement allowed in the brush holder will enable, say, a 12-light arc machine to run only one or all the 12 lamps, or any intermediate number as desired. Special provision is made for holding the brushes off the commutator by an automatic locking device. This is very useful when working with gas engines. The axle is made of steel and is very short, the bearings are three to four times as long as the diameter of the axle, the bearing frame on the pulley side is made especially strong and braces the top and bottom poles and the whole machine rigidly together. The pulley bearing on the commutator side is of bracket form, and designed to allow the connections of the armature, and the commutator and brushes to be easily got at for cleaning, and also to give the utmost possible play to the brush holder. Special arrangements are made for lubricating the bearings and collecting the waste oil.

The "Engine Dynamo" is so named from its perfected mechanical construction, by machinery, in detachable pieces. Each part of the dynamo can be quickly and easily taken apart, and in case of necessity be repaired by the purchaser or user without returning the machine to the makers. This is useful on board ship and other places where an easily repaired machine is a necessity. The armature sections and coils, the field magnets, and every part are made to steel templates and gauges; they are interchangeable and can be replaced, and the engine dynamo is specially constructed to act either as a generator of electricity or as an engine-motor for driving machinery. The arrangement of the fast and loose pulleys and striking gear (see Fig. 1.) is very compact and strong. The adjustable base is also shown, and is very simple and easily attended to.

The advantages claimed by the inventor are:—The whole machine is built up of detachable parts, which are interchangeable. The armature, which in other dynamo machines is usually the weakest part, and exceedingly difficult to repair, is in the "Engine Dynamo" very simple and strong, and easily taken to pieces and put together again. The armature coils are separately wound to an exact size, and the insulation is more perfect. The peculiar construction of the armature core obviates the loss due to Foucault currents, and allows free ventilation. The coils on both the field magnets and armature can be changed as desired, and with the same iron frame many changes in the electrical output can be obtained. The brushes, commutator, oil feeds, and other parts are strong and convenient in construction. The machine takes up less room, and is stronger built than any other dynamo machine. Many tests of these machines have been made. A very interesting test was made by completely insulating the iron sections the one from the other by thin mica plates, to ascertain if the jointed construction affected the output; but, after careful trial, the tests showed that the insulation and disjointing made no difference in the result. A machine of this type, made and tested in 1882, showed a marked improvement over a Schukert machine of a slightly larger size and heavier weight. In this case the total weight of the machine was 2cwt. 1qr. 4lb. with 58lb. of copper wire on the armature and field; this gave at 1,200 revolutions per minute an effective current of 130 volts and 8 amperes. In a recent machine made by Messrs. Blakey and Emmott, electrical engineers, Halifax, Yorkshire, who are manufacturing these machines under licence from the inventor, the results were much better with only 6lb. of copper on the armature and 30lb. of copper on the fields; a current of 1,000 watts was obtained at a moderate speed. Still better results have been obtained by a slight modification of the resistances, and at a speed of about 1,200 three arc lamps can be worked from a machine whose bulk is contained in about 2 cubic feet, and whose total weight is only about 2cwt. From recent tests it is stated the commercial efficiency of the machines has been found to be nearly 80 per cent., whilst the conversion is over 90 per cent. Messrs. Blakey and Emmott have put down special tools in their large works for the manufacture of these dynamo machines of various sizes, and for all purposes, from a one arc light machine to a 500 incandescent light machine, and wound in series, shunt or compound.

One of the most forward of the exhibits in the East Arcade is that of Mr. Swan. Several electroliers of neat and chaste design are to be seen in these exhibits. We notice that the brass work of these electroliers has been made by Messrs. Faraday and Sons, of Berners-street, and by Messrs. Winfield and Co., of Birmingham. The cut glass ornaments are by Messrs. Osler. It may not be out of place here to refer to the exhibits of Messrs. Faraday and Son, which will be found just outside the East Arcade, in the new Eastern Avenue adjoining the Printing and Chinese courts. These exhibits comprise novelties adapted for electric lighting, and some especially adapted for domestic lighting. A switch in four sizes, which has been patented under the peculiar name of the "Pointsman," is said to have several good features, such as easy manipulation, immunity from imperfect contacts, and compactness. Various lamp-holders are shown, each supposed to possess a ready means of detachment, swing brackets, portable fittings, couplets and connections for flexible wires, electroliers, brackets, and standards of various designs. These, and many other fittings in brass, of excellent workmanship will be found at this stand. Besides the work referred to as the exhibits of Mr. Swan, specimens of this firm's manufacture will also be found on view. Messrs. Woodhouse and Rawson have also supplied the fittings used in the Prince of Wales's Pavilion, and in the East Quadrant dining room. Returning now to the exhibits of Mr. Swan, we may notice various examples of miners' lamps. One complete in itself carries in a small box underneath the lamp a secondary battery, which will supply current and feed a 2½ candle-power lamp for about four hours. Others are made to use with a reel of wire, which can be unwound, and the lamp supplied from a centre when placed in the position where it is required for work. For many months past we believe experiments have been going on to test the value of celluloid for the manufacture of the filament of incandescent lamps. This material is easily manipulated, and in a plastic state can be forced through gauges so as to obtain a perfectly regular and symmetrical filament of the material, which, of course, is always to be treated and carbonised. The specimens shown were excellent examples of perfect symmetry. Whether the material will prove in use to be as good as that at present employed we cannot say, but, if it does, troubles which arise from minute differences in cellularia in the material will be overcome. A number of small Swan lamps fitted for dental and surgical purposes are also shown, as are fairy and microscopic lamps. The use of these lamps for the latter purpose is gradually extending. We may be allowed to quote from a paper which appeared in the *British Medical Journal*, of January 27th, 1883, as to the value of the surgical electric lamps designed by Mr. Payne, and used by Dr. Thomas Oliver, M.R.C.P.:—

"Dr. Oliver had previously shown these lamps applied to microscopical and clinical purposes, and he obtained from Mr. Payne an instrument by means of which the throat could be illuminated and examined. He said that, having a patient in the infirmary who was suffering from hydatid disease of the liver, on whom the operation of abdominal section with incision of the liver had been performed, he took the opportunity, and succeeded in lighting up the interior of the cyst with the electric light by means of a similar instrument, but provided with an arrangement for cooling the lamp by circulation of water, designed by Mr. Payne for the purpose, and constructed by Mawson and Swan, of Newcastle. The apparatus consists of a brass tube, electro-plated, funnel-shaped at the outer end, and securely closed at the other end with a stout piece of glass. Down this tube is inserted a narrow cylinder, which carries the Swan lamp and the electric wires. The lamp is hermetically sealed in a glass shade, and water is conveyed to and fro through very small brass tubes, and is made to circulate round the lamp to carry off all heat. To

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ensure perfect circulation of the water, as great a pressure as possible is obtained by having a tin can containing water suspended on a hook near the ceiling, and connected with the brass tube by lengths of india rubber tubing. The light from the lamp is perfectly pure, and shows things in their true and natural colour. The lamp is rendered incandescent by means of a battery of four modified Leclanché cells, which answers admirably for short periods." Dr. Oliver in his paper before the Northumberland and Durham Medical Society, said—"The tube, with its glazed extremity, was smeared with carbonised oil, although in future I shall use carbolised glycerine for the window of the tube, and with gentle pressure I succeeded in passing it through the abdominal incision into the interior of the liver. The lamp was at once lit, and by looking down the tube I had the satisfaction of observing a greyish-red condition of the walls of the cyst, studded across which were numerous yellow-white spots, evidently pus; a slight oozing or sweating was also noticed on the wall of the cavity. The illumination of the interior of the liver by means of the electric light was in every way satisfactory and successful, and although it is of little aid in the treatment of the case in question, it has shown us that the lighting up of internal cavities is not only a possibility, but a matter of comparative ease."

A large and increasing demand for the electric light is being made for its use at parties and balls, and it lends its aid to some very interesting and pretty effects in decoration. One such effect is shown in this exhibit by the placing of Swan lamps inside lemon peel. The wires are hidden by the leaves and stem of the plant, and when the connections are made, the decorations, which had previously seemed to be merely a mass of very dark green leaves, relieved by yellow globes, are beautifully illuminated. Such a system of decoration may be applied not only to fruit but to flowers, and we have seen lamps hidden among the leaves of artificial roses and other flowers which, when lighted, made a very pretty effect. Perhaps the newest piece of apparatus exhibited here is an electric meter, which cannot, however, be described without ample illustrations. The meter is for integrating time and current, and is adapted for electric lighting purposes. One of these meters has for a long time passed under trial, and has been found to work admirably.

A very interesting photo-mechanical process of printing, commonly known as "Woodburytype," is illustrated at Mr. Swan's stand by a number of specimens which have been supplied by the Woodbury Permanent Photographic Printing Company, of Ealing, W. The new system of printing consists in a combination of the principle upon which intaglio or copper-plate printing is based, and that upon which the image in carbon printing is obtained. An image, in which the shadows are in relief and the whites depressed, is obtained by exposing bichromated gelatine under a suitable cliche to the action of light, and afterwards to water. The details of the process may be varied, but we need not enter into them here, as the principle is well known. From the gelatine an electrotype is obtained with the lights in relief, and the shadows depressed, as in an engraved copper plate. This is the block or cliche from which impressions have now to be obtained by mechanical means. It must be borne in mind that the intaglio so obtained represents by degrees of depth the gradations of the image. This intaglio is now to be filled with a thick solution of gelatine, containing indian ink, or other colouring matter mixed with it; when slightly set, and the surface cleaned, as in copper plate printing, it is placed in contact with paper, the surface of which would be best prepared with gelatine, albumen, or collodion, to prevent it being absorbent; the block is then brought into firm contact by steady heavy pressure. The set gelatine and colour will be thus delivered on to the paper, much in the same way that the cook delivers a shape of jelly from its mould. The gelatine and colour so delivered on the paper will in all respects resemble a carbon print. The deepest shadows will consist of a thick opaque layer forming black, each gradation from these to white consisting of a thinner layer of the translucent material. This is really a development of the carbon printing process invented by Joseph Wilson Swan in 1864, by which the effect of light and shade on a photograph is obtained by a coating of gelatine, coloured with carbon, and rendered sensitive to light by bichromate of potash, and which is rendered insoluble, by exposure to light under a negative, to varying depths corresponding to the varying degrees of transparency in different parts of the negative, the stratum not affected by the light being afterwards washed away. Mr. Swan proposed that the intaglios from which the prints or castings were made should be produced from the gelatine relief by the electrotype process. This method of producing the intaglio mould was subsequently modified by Mr. Woodbury, who found it advantageous to employ a lead plate, on the surface of which a reverse of the gelatine relief was obtained by means of hydraulic pressure. A specimen of an electrotype intaglio, and also of an intaglio produced on lead by pressure are shown. The most interesting feature of the process is the peculiar method of printing employed—a sort of cross between printing and casting—and which is as distinct from other methods of printing as lithography is distinct from letterpress. The following particulars will make clear how the printing from lead or electrotype intaglio is effected:—A warm solution of gelatine, coloured, as in the carbon process, with carbon or other pigments, is poured upon the centre of the intaglio, and a sheet of very smooth paper, backed by a perfectly true plane surface of metal, is brought down upon it, so as to expel the superfluous gelatine solution from between the paper and the surface of the intaglio and leave the depressions filled. After allowing the gelatine solution (which may be termed the ink) to completely set, the paper is lifted off and carries with it the solidified gelatine casting, a perfect counterpart of the intaglio. The print is then immersed in a solution of alum, which renders it insoluble. The result is that, as the coloured gelatine solution or ink is semi-transparent, those parts of the print which correspond to the deeper parts of the intaglio will be darker in tint than where the stratum of gelatine is thinner.

On the opposite side of the Arcade we note perhaps the most complete of all the exhibits, that of Messrs. Davis and Timmins, who show an excellent assortment of their manufacture in brass screws. Terminals of all sorts and all sizes are to be seen here, as well as specimens of wire used for electrical purposes. Mr. Meyer, of Liverpool, shows specimens of his system of laying underground wires for lighting, telegraphic, and other purposes. Close by is also the exhibit of the Kinetic Engineering Company, showing specimens of the Berthoud-Borel system of electric cables. We have so often referred to these that it is impossible to say anything new about them.

The Electrical Power Storage Company, whose exhibit, however, is not yet complete, have some fine examples of their most recent form of cells. There is no doubt but that every improvement added to secondary batteries brings us nearer to the time when they will become altogether reliable, and take their proper position in every electric light installation. The principal improvements are necessarily in the details relating to the form of the plate, the connections, and the containing cell. From impartial users of the most recent forms we hear that the improvements are real. Other exhibitors of storage batteries are the Consolidated Electric Company, whose batteries on the B. T. K. system are also used in the lighting of the tunnel, the current for charging the batteries being supplied by Messrs. Goolden and Trotter from one of their Halifax machines, under the supervision of Mr. Beeman. Mr. Planté, again, has an exhibit, which as yet has proved one of the most attractive in the Arcade. It is ready—and an attendant is there to explain fluently and simply the apparatus shown.

One of the largest, most important, and most complete of the exhibits is that of Messrs. Laing, Wharton, and Down; and fuller reference will hereafter be made to this exhibit, including as it does the apparatus connected with the Thomson-Houston system of lighting.

The Vulcan Manufacturing Company show specimens of their work, which is devoted principally to the construction of all that pertains to electric bells. A large variety of portable bells, of pushes, connections for house, ship, and public work, are on view. The workmanship, so far as we have been able to examine it, is excellent.

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NOTES.

THE ELECTRIC LIGHT IN BELGIUM.—The offices of our contemporary, the *Moniteur Belge*, are to be lighted electrically.

THE HOTEL METROPOLE.—In this hotel about 70 miles of electric and bell wire have been used to connect up the various rooms.

ELECTRIC LIGHTING.—Tenders for the lighting of the town of Dundalk by electricity are invited in our advertisement columns.

NEW INSULATING MATERIAL.—It is said that MM. Berthoud and Borel are preparing a new insulating substance into which boiled linseed oil enters largely.

THE REDON ELECTRICAL BELL.—The electrical bell of M. Redon, lately exhibited at the Observatory in Paris, is an improvement upon the apparatus in common use.

THE TELEGRAPH IN ALGERIA.—The financial position of the Algerian telegraph is a prosperous one; the receipts having been augmented of late in a remarkable manner.

THE NEW ORLEANS EXHIBITION.—A Reuter's telegram, dated New Orleans, May 20, says the New Orleans Exhibition will be closed on the 31st inst., but will reopen in November next.

A NOVEL APPLICATION OF POWER.—A small Guimaraes motor, worked by a primary battery, has been ordered by an enterprising American for the purpose of hoisting a letter box four stories.

THE MANUFACTURE OF BICHROMATE OF SODA.—The manufacture of bichromate of soda as a substitute for bichromate of potash in primary batteries is being actively carried out by M. C. S. Sorman.

THE B.T.K. SYSTEM.—A merchant writing from Colchester to the Consolidated Electric Company expresses his satisfaction with the electric light which has been in use in his offices for about eight months.

THE INVENTORIES.—The continuation of our report of the Exhibition is postponed to our next issue in the hope that the arrangement of the electrical exhibits will have approached completion by that time.

EFFECTS OF LIGHTNING IN FRANCE.—The number of persons killed by lightning in France since 1835 is 4,609. During 30 years, that is to say, since 1854, 2,222 men and 929 women have been destroyed.

THE ELECTRIC LIGHT AT BANGOR, ME.—The city of Bangor, Me., is now lighted by the Thomson-Houston system, the plant having been put in by the American Company of Boston. The present capacity is 114 arc lights.

SOCIEDAD ELECTRICA.—Under the above title a society has been constituted in Barcelona by D. Narciso Xifra, an engineer, for the construction, installation, and maintenance of the most modern forms of electric light and other apparatus.

THE GIME ACCUMULATOR.—The sole advantage seemingly possessed by the new accumulator of M. Gimé is that the plates when used can be removed with greater facility than is usual with the ordinary types of secondary batteries.

THE VAN RYSSELBERGHE SYSTEM.—Induction has been giving so much trouble in Switzerland, that the administration of the telegraphs of the Confederation have decided to adopt the Van Rysselberghe system between Lausanne and Geneva.

NOTICE OF REPAIR.—The Eastern Telegraph Company announce the repair of the Eastern and South African Company's Zanzibar-Mozambique cable, thus re-establishing telegraphic communication with the East Coast of Africa, Natal, and the Cape of Good Hope.

THE ELECTRIC LIGHT IN CHICAGO.—Both incandescent and arc electric lights will be used in the New Chicago Board of Trade Building, and the light plant in the basement is a valuable one. The main hall is lighted by four large sun burners and twenty arc lights extending around the hall.

THE SOUDAN TELEGRAPHS.—The Cairo correspondent of the *Daily Telegraph* says:—The greatest regret is expressed here at the decision to refer the settlement of the dispute about the payment for the military use of the Soudan telegraphs to arbitration, and it is considered that an exhibition of vigour by England would be very opportune.

FASTNET SIGNAL AND TELEGRAPH STATION.—The laying of the submarine cable connecting Lloyd's signal station on the Fastnet Rock with the mainland at Crookhaven has been successfully accomplished. Vessels which pass this station and wish to be reported can now be signalled and reported by telegraph direct from the signal station on the Rock.

ELECTRIC LIGHTING OF TRAINS.—The Lancashire and Yorkshire Railway Company are trying the experiment of lighting the express trains between Manchester and Liverpool, Leeds, Bradford, and York, by means of electricity. The system has been in operation two or three days, and has proved very satisfactory. The lamps used are those of Woodhouse and Rawson of 10 candle-power.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—A meeting of this society will be held at the Institution of Civil Engineers, 25, Great George-street, on Thursday, 28th inst., when the following papers will be read:—"On Ship Lighting by Glow Lamps, Embodying Results of Trial for Economy in H.M.S. 'Colossus,'" by B. J. Farquharson, member; "Electric Lighting at the Forth Bridge Works," by J. N. Shoolbred, B.A., M. Inst. C.E., member.

A GOOD OPPORTUNITY.—An announcement will be found in our advertisement columns to the effect that a gas company in a small borough in the midland counties is charging four shillings per 1,000ft. for gas as supplied to public lamps, and four shillings and sixpence to private consumers. Every assistance and facility would be given to a company which could supply the electric light to the whole or the principal part of the borough at a less cost than that now paid for gas. Come on, electric light companies!

THE SOUDAN MILITARY TELEGRAPH.—The line of military telegraph between Cairo and Korti, 1,123 miles in length, seems to be both efficiently worked and maintained. The principal stations are Cairo, Assiout, Assouan, Korosko, Halfa, Dal, Dongola, Debbeh, and Korti, while branch stations have been opened at Shellal, Gemai, Serras, Mohrit, Ambigole, Akasha, Abu Fatmeh, and Merawi. Between Assiout and Assouan, a distance of 320 miles, translaters are in use, and these are worked with about 30 volts, a fact which speaks well for the insulation of the line.

THE ELECTRIC LIGHT IN MINES.—The installation in the lead mines of Mechernich, Eifel, is giving great satisfaction. The space lighted is about 650 metres in length by 340 in breadth, and 104 in depth, and this is accomplished by means of two Siemens arc lamps of 3,000 candle-power each. The total cost of the installation has been £550, which includes

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also 10 arc lamps of 350 candle-power each in the galleries, while the cost of the light per hour is said to be 1s. 11d. as against 2s. 6d. for oil, &c. Another installation of nine Siemens lamps is in course of projection.

THE FAWCETT MEMORIAL FUND.—The sum collected towards the fund for the national memorial to the late Postmaster-General by the servants of the Post Office now amounts to £918. 3s. 8d. At the influential meeting presided over by the Lord Mayor on Wednesday it was decided that the national memorial should take the form of (1) a tablet in Westminster Abbey; (2) a scholarship tenable by a blind person at any university, including women's colleges; (3) the promotion of the higher education of the blind in connection with the Royal Normal College and Academy of Music at Upper Norwood.

DOMESTIC ELECTRIC LIGHTING.—On Tuesday evening last, May 19, Mr. F. Geere Howard, of Cleveland-street, W., lighted up a greater part of Mrs. Robert Smith's house in Dover-street, Piccadilly, on the occasion of a ball given that evening. The ball room, supper room, and three other rooms, besides the vestibules, passages, &c., were entirely lighted with incandescent lamps, shaded with ground opal and pink glasses. In all 39 Swan lamps of 20 candle-power each were used, the current being obtained from fifty 1 horse-power accumulators supplied by the Electrical Power Storage Company. The cells were left in their van in the coach house belonging to the house.

ELECTRICAL NOTATION AND NOMENCLATURE.—The system introduced by M. Hospitalier at the last meeting of the Society of Telegraph-Engineers and Electricians commends itself to us generally, but it is to be hoped that among other things the symbols C for *current* and Cp for *capacity* will finally be adopted. The French I, representing *intensity*, does not sufficiently convey the idea of *current*, and it is liable furthermore to lose itself on a long equation where arithmetical unity occurs with any frequence. K, as symbolical of *capacity*, is objectionable in that the Greek κ is almost universally used for coefficient. This question, however, is treated at length in another part of our present issue.

THE ELECTRIC LIGHT IN NEW YORK.—The New York Gas Commission have awarded the following contracts for lighting the streets:—The United States Illuminating Company, lighting with electric light the streets and parks now lighted by said company and the following in addition: Catherine-street (from Chatham-square to the East River), Chambers-street (from Broadway to the North River), Fulton-street (from the North to the East River), and Canal-street (from Bowery to the North River), at 70 cents per night for each lamp; the Brush Electric Illuminating Company for lighting by electric lights the streets and lamps now lighted by said company at 70 cents per night for each lamp; the Equitable, the Mutual, and the Central, the Northern and the Yonkers Gas Light Companies for all the streets on their mains except those lighted by electric lights.

THE ELECTRIC LIGHT IN PARIS.—*Apropos* of the installation at M. Boudet's shop in the Boulevard des Capucines in Paris, mentioned in our issue of May 9th, the Société le Chrome inform us that after some experiments upon a dozen lamps it was decided to light the whole of the shops on the ground floor with 72 lamps, and this installation was put down and started on the 20th ultimo. The lamps are Woodhouse and Rawson of 40 volts, and are arranged three in series and six in multiple arc, making four groups of 18 lamps. These are fed by four primary batteries of 100 cells, each containing chromic acid manufactured at the works of the Société le Chrome at St. Ouen from ore from New Caledonia. As chromic acid does not attack zinc when the battery is not in action the zincs are left in the liquid. As regards the price it is said to be very little over that charged in Paris for gas. It is proposed, we believe, to add a number of large Gramme regulators to this installation, and in September next to extend the number of lamps to 300.

NEW TELEPHONE COMPANY.—A circular is about to be issued by this company calling attention to Prof. Silvanus P. Thompson's patent telephones now manufactured by them. In the transmitting instrument the use of a tympanum to catch the sound of the speaker's voice is obviated by the employment of a funnel-shaped tube; and instead of the tension regulator or carbon-button used by Edison, there is a metallic ball-valve. This combination of a speaking tube with a ball-valve to control the electric current is one of the most novel points of the new invention, and is as simple as it is novel. In the receiving instrument at present used by the New Telephone Company the vibrating diaphragm consists of a piece of gold-beater's skin properly prepared, carrying at its centre a bit of thin iron about as big as a thumb nail; this is placed in front of an electro-magnet, which is excited by a current from a battery in the line wire. The price fixed for the two complete sets of instruments required for the two ends of the line is a moderate one.

TELEGRAPH ACTS AMENDMENT BILL.—On Tuesday evening Lord J. Manners said that this Bill was down for Friday, but he would like the second reading postponed until after Whitsuntide.—Mr. Shaw-Lefevre did not understand that the noble lord was opposed to the second reading, but objected to some of the details. If the Bill was to come into operation in August next, it was necessary that the second reading should be passed before Whitsuntide, otherwise it would be impossible to make the arrangements for the sixpenny telegrams. He suggested that the noble lord should allow the second reading to be taken on Friday, and that the discussion should be postponed until the Committee stage.—Lord J. Manners subsequently said that he had no alternative but to accede to the suggestion of the right hon. gentleman, and he therefore gave notice that he should postpone his amendment till the Committee stage.—A morning sitting for the second reading of the Sixpenny Telegrams Bill will accordingly be held this day (Friday), the House adjourning at 7 o'clock for the holidays.

A NEW COMPETITOR FOR THE ELECTRIC LIGHT.—On Wednesday evening at the invitation of Mr. Alfred Ridsdale, of the Minories, London, a number of gentlemen assembled at the Criterion to inspect a new system of railway carriage illumination by means of Shallis and Thomas's patent mineral oil roof lamps for oils from 120° to 250° flashing point. The advantages claimed for the new lamp are substantially as follow:—Absence of shadow; perfect steadiness of light at whatever speed the train be running; ventilating properties; brilliant power of light; and economy, in that in comparison with the lamps ordinarily in use for railway carriage lighting a saving of 70 per cent. is effected in cotton waste for cleaning purposes, of 150 per cent. in cotton wicks, of 65 per cent. in oil, and of 60 per cent. in repairs. The light as we saw it on Wednesday evening was a marked improvement upon that common to public vehicles, and was certainly very steady. Altogether we must congratulate the inventors of the new system upon the result of their labours.

GAS VERSUS ELECTRICITY IN NEW YORK.—The Secretary of the Gas Commission has reported to the City of New York regarding the relative cost of gas and electricity for lighting

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streets. The city has 647 electric lights, costing annually £33,061. 14s. These displaced 3,016 gas lamps, costing £10,556. The Common Council has requested that 2,093 additional electric lights be put in use, displacing 5,345 gas lamps. The cost of these electric lights will be £106,952. 6s. a year, while the gas lamps over the same area cost £18,707. 10s. Should the additional electric lights be authorised, there will be on Manhattan Island 2,740 electric lights, costing £140,014, and 13,685 gas lamps, costing £46,597. 6s. As the cost of lighting the Twenty-third and Twenty-fourth wards is £23,526, the entire cost of lighting the city would be £210,137. 6s. This is one way of putting the cost, electric lamp *versus* gas lamp! The advocates of gas take good care to withhold all discussion as to areas efficiently illuminated, and make no mention of the respective number of candles given in each case.

Lord Salisbury on the Electric Lighting Industry.—In the course of his speech, on the occasion of the annual dinner of the Middlesex Conservative Association on Wednesday last, Lord Salisbury made the following remarks:—"Mr. Chamberlain is not the originator of the idea of ransom. There are picturesque persons, travellers will remember, in Sicily and Greece, who are very familiar with the word 'ransom,' but they are not supposed to exercise a beneficent influence upon the lands they condescend to occupy. Mr. Chamberlain has had under his hand a certain industry—electric lighting. He was not willing to give them free scope, but he thought he could get a ransom, and he desired that at the end of twenty-one years any enterprise these electric lighting companies might set up should be confiscated for the benefit of the municipality in which they acted. This shows you how this plan of exacting ransom has answered. Bankruptcy has followed, I believe, nearly every one of these companies, and what is, in America, marching on with giant strides and contributing to the comfort of the people is here entirely strangled."

The Telephone in Berlin.—The *Pall Mall Gazette* says:—"The development of the telephone in the hands of the German Post Office is a further witness to the better side of paternal government. The telephone has been largely taken advantage of for private communication between offices, warehouses, and private residences, but the main use of it is in connection with the Exchange. Berlin has an Exchange with over 2,500 members. There are offices at the Central Telegraph Office, Oranienburger Strasse, Unter den Linden, Halle Gate, Köpnicker Strasse, and Central Market. At these offices a numbered list of the members may be seen, this list being also supplied by the Post Office to each member and the additions periodically intimated. Any one desiring to speak to a member may enter an office and request to be put in communication with Number So and-so. The fee for this is 50 pfennig, and the time allowed is five minutes. This time, however, is not strictly observed, unless a second person is waiting to speak with the same member. When the conversation is finished a bell is rung at the central office. This, indeed, is a popularising of the telephone, which not only citizens, but visitors to Berlin who take the trouble to familiarise themselves with the Post Office arrangements, may employ to the great saving of time and trouble."

Combined Arc and Incandescent Lighting.—Having regard to our remarks on this subject in our last issue, the *Tecnomasio Italiano* of Milan write to inform us that since the month of November, 1884, the steamboat "Regina Margherita," belonging to the firm of Rocco, Piaggio, and Sons, of Genova, has been successfully and efficiently lighted by a combined system of 100 16 candle-power incandescent and 4 arc lamps, the latter being placed in multiple arc with the incandescents, and regulated by a series of resistances. These lamps are all served by a machine manufactured by our informants. The same system was employed by the *Tecnomasio Italiano* during the winter of 1884 for the illumination by arc lamps of the theatre of La Scala at Milan. In this installation the dynamo served at the same time eight arc lamps in multiple arc, and a certain number of incandescent lamps of 100 volts. The difference of potential in this case was reduced by means of the resistance furnished by the 100-volt lamps, of which the number varied according to the intensity of the arc it was wished to form. When the carbons were in contact the incandescent lamps were at 100 volts, but as soon as the carbons were parted they fell to an incandescence corresponding to about 50 volts. In point of fact the resistance of each circuit remained constant, whether the arc was formed or not. With this system, when an arc had to be extinguished for the requirements of the service, by approaching the carbon to a point of contact, the other arcs which remained in action experienced no variation whatever by reason of the incandescent lamps acting automatically as resistances, and the quantity of current passing in any portion of the circuit underwent, practically speaking, no perceptible alteration. We are further informed that the above arrangement is due to Mr. Emilio Cabella, a young electrician of Milan. The installation at La Scala Theatre has given such satisfaction that the management have decided upon the final adoption of the electric light.

Salvage by a Telegraph Steamer.—Valuable salvage services have been rendered by the telegraph cable steamship "Minia," belonging to the Anglo-American Telegraph Company, to the barque "Hudson," her cargo and freight, in the Atlantic Ocean, in April last. On the 28th of March the "Minia" left Halifax, Nova Scotia, for the purpose of repairing the Brest-Saint Pierre cable, which had been broken about lat. 48.34 north, and long. 11 west; she had about eighty miles of telegraph cable, besides other telegraphic appliances, and was manned by a crew of eighty-five hands. The weather was very tempestuous during the voyage, and on the 8th of April, when the "Minia" was in lat. 46 4 north, and long. 14 26 west, a dismasted barque, which proved to be the "Hudson," was sighted about seven miles off, flying signals of distress. The course of the "Minia" was altered, and having approached the "Hudson" it was ascertained that she was 145 days out from Java, bound for Falmouth with a cargo of sugar. Her main and mizen masts had been carried away close to the deck, her foretopmasts had gone at the cap, and she had suffered other serious damage. At first the master of the "Minia" declined to take the "Hudson" in tow, on account of the urgency of the business on which he was engaged, though he offered to take off her crew; but eventually, at the earnest solicitation of the master of the "Hudson," he agreed to make an attempt to save the barque. Hawsers were then passed between the two vessels, and the "Minia" commenced to tow the "Hudson" towards Falmouth at slow speed. On the following day the wind increased, and additional hawsers were made fast as a precaution. The towage continued at varying speeds until about 5:30 p.m. on the 12th April, when the "Minia" brought the "Hudson" in safety into Falmouth, having towed her a distance of 490 miles. The value of the "Hudson," her cargo, and freight was £17,685. The sailors have been awarded £1,500, apportioned as follows:—£900 to the owners of the "Minia," £200 to the captain, and £400 to the crew.

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THE ELECTRIC LIGHT FOR WAR SHIPS.—The Italian cruiser, "Giovanni Bausan," built and armed by Sir W. G. Armstrong, Mitchell, and Co., Newcastle-on-Tyne, and commanded by His Royal Highness the Duke of Genoa, left the Tyne, on her official speed trial, on the 11th inst., and during a prolonged trip of over six hours maintained her exceedingly high mean speed of over 17½ knots per hour. The vessel, which with her powerful armament of Armstrong guns and Whitehead torpedos is probably the most redoubtable cruiser in the world, is fitted throughout with the electric light. Two Gramme dynamos, driven by Brotherhood three-cylinder engines, supply the required electric current, and together with 32 one horse-power electric accumulators, manufactured expressly for ship use by the Electric Power Storage Company, and enclosed in teak boxes, instead of the usual glass cells, are placed in the after torpedo chamber, where is also fitted a switch-board controlling the nine distinct circuits into which the lamps (arc and incandescent) are divided. The incandescent light circuits are as follow :—

Passages, deck houses, and captain's cabins	43
Cabins and mess rooms	44
Coal bunkers	18
Engine room	20
Stoke holds, fan rooms, and hydraulic engine room	28
Torpedo room	6
Magazines and steering gear	11

which, with six pilot lamps in the electric engine room, make up a total of 176 lamps, all of which are of the Edison eight candle-power, 51 volt pattern. Each cabin has one or more lamps, and these are throughout fitted with individual switches. The separate circuits are distinct, and can be controlled direct from the switch-board. The ship is also fitted with two search arc lights of 20,000 candle-power placed on the forward and after gun loading stations respectively. The ordinary practice on board is to start the dynamos to charge the accumulators during the afternoon, keeping them running during the evening until the cabin lamp circuit is switched off, when the dynamos are stopped, and the accumulators serve to maintain the passage lamps throughout the night. The accumulators are also employed to maintain a portion of the incandescent lamps when the dynamos are feeding the search lights, and are, moreover, a very useful reserve in case of any accident to engines or dynamos, or when only one or two lamps are required. The wires, which are fitted upon the double return wire system, are enclosed throughout in grooved teak or pine casing. The entire fitting up of the installation has been performed by the builders, Messrs. Sir W. G. Armstrong, Mitchell, and Co. The vessel is expected to leave for Italy in a few days.

SIXPENNY TELEGRAMS.—Extensive preparations are being made by the Post Office Authorities for the new system of sixpenny telegrams. The extensions have been made on the basis of an estimate that the reduction in tariff will cause an increase of the business of the department to the extent of 30 per cent. within the first year, and the extra expenditure already incurred amounts to half a million sterling. Of this amount £475,000 has been spent on new plant—poles, wires, instruments, &c., whilst £25,000 has been laid out in the erection of new buildings. This comparatively small proportion for the latter purpose is due to the fact that accommodation for future development had already been provided in most of the post offices built or extended within the last two or three years, including those at London, Manchester, Bradford, York, Exeter, and Plymouth, Glasgow and Aberdeen, Cardiff, Dublin, Belfast, and Cork. The length of public road upon which new poles have been erected in England is 850 miles, apart from the extension on railway routes, and upon these poles there have been placed 9,200 miles of new wires, in addition to which there are about 11,600 miles of new wires put up on existing road or railway poles. Three new trunk lines have been formed, the first from London *viâ* Peterborough, Doncaster, York, and Pierce Bridge (Darlington), to Newcastle; the second from London, *viâ* Aylesbury, Widnes, Leamington, then north of Birmingham to the west of Chester, half-way between Liverpool and Manchester, through Wigan, and then by way of Lancaster to Carlisle; the third, over the South Western line to Basingstoke, through Andover and Salisbury to Exeter—each with branches at various points from the main circuits. Similar extensions on a somewhat smaller scale have been made in Scotland and Ireland. A number of new three-wire submarine cables, for service under channels, rivers, and lakes, have also been provided for the convenience of the Isle of Man and the Orkney and Shetland Islands. In London the number of offices at which the pressure of business is met by the use of pneumatic tubes, will be increased by the use of an additional length of 7,500 yards of tube. Among the additional instruments purchased are 40 Wheatstone automatic, eight quadruplex, 300 duplex sounders, 350 single sounders, 150 single needle machines, and 10 extra repeaters. The duplex system will be completed in the case of 100 circuits. The staff throughout the kingdom will be increased to the extent of 1,200 new telegraphists and over 1,000 messengers.

SIR W. THOMSON AND MAXWELL'S ELECTRO-MAGNETIC THEORY OF LIGHT.—From a letter written to *Nature*, by Prof. G. F. Fitzgerald, on the subject of the electro-magnetic theory of light, we extract the following:—"Sir William Thomson has clearly pointed out a direction in which to look for a true wave-propagation. It will make his position clearer, and also Maxwell's, to use his analogy between water in an elastic tube and a conductor of electricity. I will suppose the water contained in a tube bored out of a very large lump of india rubber. He enumerates three electric qualities concerned, and their hydrodynamic analogues:—(1) 'Charge' or electrical accumulation in a conductor subjected in any way to the process of electrification. (2) 'Electro-magnetic induction' or electromotive force excited in a conductor by variations of electric current. (3) Resistance to conduction through a solid. The hydrodynamic analogues are:—(1) Accumulation of a greater or less quantity of water in any part of the canal or tube. (2) Inertia of the water. (3) Viscosity or fluid friction. He explains that a true wave-propagation arises from the compressibility of the water, combined with its inertia, and that if the tube be elastic, like india rubber, there would also arise a wave-propagation. 'Accordingly,' he says, 'a definite velocity of propagation of electric impulses, depending on the inertia and the capacity for charge, is to be looked for, as has been done in a first article, published by Kirchhoff, on the subject.' Now, in all this discussion Sir William Thomson omits to mention the only thing that is at all analogous to Maxwell's propagation of wave disturbances in non-conductors, and it arises from his considering the water as contained in a tube like ordinary india rubber tubes, instead of in a tube bored in an indefinitely large lump of india rubber. If we consider this case it is evident that one of the conditions to be considered is the propagation of waves in this lump of india rubber. In Sir William Thomson's tube there would of course be a velocity of wave-propagation in the india rubber, but that is a very different matter from the propagation of disturbances away from the neighbourhood of the tube by which energy would be carried away from it. To do this Sir William

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Thomson should have included the propagation of sound in the air or whatever he supposed surrounded the outside of his tube. Without including this, he was not including anything a bit analogous to Maxwell's electro-magnetic theory of light. In Sir William Thomson's tube the whole state of affairs at any time could be expressed in terms of variables that represented bodies near the tube, while in the other case it would be absolutely necessary to introduce variables representing every part of the india rubber which I have supposed of indefinite extent. This is just the difference between Sir William Thomson's and Maxwell's views. According to Maxwell's view there is a great deal more going on outside the conductor than inside it, and it is evident that the inertia of the water is a very bad analogue to electro-magnetic induction, for this latter depends essentially upon the form of the circuit, and not only upon its section and length. Maxwell has shown that light may be a wave-propagation of what are on his theory *analogous*, though probably utterly *unlike* the distorsional waves propagated in the india rubber, and has shown that a medium which would only transmit disturbances analogous to these would explain electric and magnetic phenomena. It is to be remembered that Maxwell's theory gets rid of all action at a distance, and that the only *experimentum crucis* between theories of action at a distance and of action through a medium is that in this latter case the energy may be propagated in time through the medium, while in the former it cannot. Sir William Thomson's speaking of the ether as *like* a jelly must be strongly protested against. It is in some respects *analogous* to one, but we certainly know a great deal too little about it to say that it is *like* one. May be Maxwell's conceptions as to its structure are not very definite, but neither are any body's as to the actual structure of a jelly, and there is no real difficulty in supposing a medium whose condition is represented by symbols that obey the laws that Maxwell has shown should be the laws of symbols representing the condition of a medium that would explain electric and magnetic phenomena. It seems very unlikely that any jelly is at all *like* the ether that Maxwell supposes. It seems much more likely that what he 'called electric displacements' are changes in structure of the elements of the ether, and not actual displacements of the elements. He guards against this being supposed a necessary part of his theory when he defines polarisation in terms that certainly require a change of structure rather than a change of position, so that I think the word 'displacement' was unfortunately chosen. I also think that Sir William Thomson, notwithstanding his guarded statements on the subject, is lending his overwhelming authority to a view of the ether which is not justified by our present knowledge, and which may lead to the same unfortunate results in delaying the progress of science as arose from Sir Isaac Newton's equally guarded advocacy of the corpuscular theory of optics."

THE ELECTRIC LIGHT IN THE "IRISH TIMES" OFFICE.—At a meeting of the Royal Dublin Society held on the evening of the 18th inst., under the presidency of Mr. Howard Grubb, F.R.S., Mr. J. A. Fahie, C.E., read a paper on "Notes on a Year's Working of an Electric Light Installation," from which we extract the following:—"The following notes of twelve months' actual working of an electric light installation will doubtless be of interest. The installation here referred to is that at the offices of the *Irish Times*, which was fitted up in January, 1884, so that a year's working was completed in January last. The dynamo-electric machinery consists of a Siemens alternate-current machine, and a shunt wound continuous-current machine as exciter. These machines are capable of feeding 150 incandescent lamps at a brilliancy of about 17 candles each. The lamps used are of the Swan type, arranged in parallel circuit, and fixed to the gas fittings wherever practicable. The motive power is derived from two gas engines of the Crossley type, which are coupled up to a counter-shaft from which the dynamos are driven, so that one or other of the engines may be used at pleasure. These engines are each 12 horse-power, and are provided with a pair of heavy flywheels to ensure steadiness of motion. The lamps burn remarkably steady, there being no pulsation whatever visible in the light. The installation is worked on an average eight hours every night throughout the year, except Saturday, and not one working night has been missed since the commencement. The principal portion of the building lighted electrically is the composing room, in which there are about 120 lamps. This apartment, which measures some 60ft. by 40ft. by 70ft. in height, was formerly lit by the same number of gas jets. The temperature frequently ran as high as 85 degrees in winter and 95 degrees in summer. Since the introduction of the electric light the air is pure and wholesome, the thermometer rarely marking higher than 70 degrees during the night. Now, as to the cost of working this installation, which is really the all-important consideration. It must be understood that gas is not wholly superseded; it is partly used in the editorial department, and also in the offices before the electric light machinery is set in motion, as it is not considered economical to start the dynamos until a certain number of the compositors have commenced work. The usual time of starting is about 7 p.m., and the machinery is kept running during the night until three and sometimes four o'clock in the morning, with a pause of half an hour at supper time. In summer, however, the light is run continuously during the night, it being desirable to keep the temperature as cool as possible. During the twelve months' working a saving of about £120 was effected in the gas account, and this saving covered the interest on the cost of the electrical plant, the breakage of lamps, the wear and tear on the machinery, and the attendant's proportion of wages. The dynamo machinery performed 2,200 hours' work during the year, absorbing 19 indicated horse-power. This power was obtained at an expenditure of 418 cubic feet of gas per hour (*i.e.*, 22 cubic feet per horse-power per hour). The dynamo machines gave no trouble during the year, and needed no repairs; and they are now, after sixteen months' work, in good condition. Considering that the installation was worked for 2,200 hours, it is satisfactory that only 56 lamps were destroyed; of these about 15 were broken through carelessness or by accident, so that only 41 gave way owing to rupture or burning out of the carbon filaments. This, it must be admitted, is a very moderate loss in lamps. The average life of a lamp burning at its normal candle-power is usually estimated at 1,000 hours; but here we have several lamps running considerably longer than 2,000 hours. The long life of the lamp in the present case may be accounted for in two ways—1st, they are not incandesced to their normal power (being 20-candle lamps and run only at 17 candles); and, 2ndly, they are worked by alternate-current dynamo machinery. It is remarkable to note how considerably the life of a lamp is affected by a difference in the E.M.F. under which it is worked. Taking the actual work done in the installation under notice, and assuming that the average number of lamps run for the 2,200 hours was 130, we find the total cost of working is £278. 2s. 6d. This represents a fraction less than a farthing per lamp per hour—just about the same price as an ordinary gas jet burning five cubic feet per hour. From this it follows that the electric light, when used on a moderately large scale, can be maintained, lamp for lamp, at the same cost as gas."

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ALTERNATING CURRENTS.

BY THOMAS H. BLAKESLEY, M.A., M. INST. C.E.

(Continued from page 511, Vol. XIV.)

These formulæ enable a comparison to be made of the squares of the currents, as indicated by a dynamometer, at different points of a line. The dynamometer readings will be as before $\frac{(\text{maximum I})^2}{2}$, that is to say,

$$\epsilon^2 \frac{C\pi}{2T\rho} \cdot e^{-2ax} \left\{ 1 + e^{-4a(l-x)} + 2 \cdot e^{-2a(l-x)} \cos 2a\overline{l-x} \right\}$$

This, when $x = 0$, is equal to

$$\epsilon^2 \frac{C\pi}{2T\rho} \cdot \left(1 + e^{-4al} + 2 \cdot e^{-2al} \cos 2al \right)$$

and, when $x = l$, it has for value

$$\epsilon^2 \frac{C\pi}{2T\rho} \cdot e^{-2al} 4.$$

The relation of the former to the latter is therefore

$$\frac{1 + e^{-4al} + 2e^{-2al} \cos 2al}{4e^{-2al}}$$

$$= \tfrac{1}{4} \left\{ e^{2al} + e^{-2al} + 2 \cos 2al \right\} \quad . \quad . \quad . \quad (\epsilon)$$

Which is equal to the series

$$1 + \frac{(2al)^4}{\underline{|4}} + \frac{(2al)^8}{\underline{|8}} + \ldots$$

and, therefore, always more than unity, however small l may be. Hence the dynamometer reading is a minimum at $x = l$.

This case corresponds to that of an alternating current machine in connection with a uniform cable possessing capacity. The point $x = l$ corresponds to a point of the cable half way between the terminals of the machine, at which point the potential is zero always, and ϵ corresponds to half the E.M.F. of the machine.

The comparative reading of the dynamometer at any point distant l from the central point in either direction will be

$$1 + \frac{(2al)^4}{\underline{|4}} + \frac{(2al)^8}{\underline{|8}} + \&c.$$

It is clear, therefore, that three readings of the dynamometer at points at measured distances apart from one another will suffice to determine the value of a, and $a = \sqrt{\rho \frac{C\pi}{2T}}$; therefore, if ρ, the rate of resistance, and 2 T, the periodic time, are known; C, the capacity of a unit of length of the conductor, can be accurately determined.

If we employ the symbols of hyperbolic trigonometry the expression (ϵ) may be written

$$\frac{\cosh 2al + \cos 2al}{2},$$

that is to say, the relation between the dynamometer readings at any point distant l from the central point or point of no potential, and at that central point is expressed by the mean of the hyperbolic and circular cosines, a result given before the Society of Telegraph-Engineers and Electricians by the author.

If there had been an ordinary conductor possessing no electrical capacity, but of such a resistance, B, that an alternating E.M.F. corresponding to the potential existing in the condenser cable at a point, viz. :—

$$\epsilon \cdot e^{-ax} \left\{ 1 + e^{-4a(l-x)} - 2e^{-2a(l-x)} \cos 2a(l-x) \right\}^{\frac{1}{2}}$$

would produce the same effect on the dynamometer as is observed, then

$$\frac{\epsilon^2 e^{-2ax} \left\{ 1 + e^{-4a(l-x)} - 2e^{-2a(l-x)} \cos 2a\overline{l-x} \right\}}{2B^2}$$

$$= \frac{\epsilon^2 C\pi}{2T\rho} e^{-2ax} \left\{ 1 + e^{-4a(l-x)} + 2e^{-2a(l-x)} \cos 2a\overline{l-x} \right\}$$

We deduce

$$B^2 = \frac{T\rho}{C\pi} \left\{ \frac{1 + e^{-4a(l-x)} - 2e^{-2a(l-x)} \cos 2a(l-x)}{1 + e^{-4a(l-x)} + 2e^{-2a(l-x)} \cos 2a\overline{l-x}} \right\}$$

When $x = 0$,

$$B = \sqrt{\frac{T\rho}{C\pi}} \cdot \left\{ \frac{1 + e^{-4al} - 2e^{-2al} \cos 2al}{1 + e^{-4al} + 2e^{-2al} \cos 2al} \right\}^{\frac{1}{2}}$$

If $2al = \theta$, for brevity

$$B = \sqrt{\frac{T\rho}{C\pi}} \cdot \left\{ \frac{\frac{\theta^2}{\underline{|2}} + \frac{\theta^6}{\underline{|6}} + \frac{\theta^{10}}{\underline{|10}} + \ldots}{1 + \frac{\theta^4}{\underline{|4}} + \frac{\theta^8}{\underline{|8}} + \ldots} \right\}^{\frac{1}{2}}$$

When $\theta = 0$ the term in the bracket is equal to zero, when $\theta = \infty$ it is equal to unity.

Thus B increases from zero to $\sqrt{\frac{T\rho}{C\pi}}$, as l increases from zero to infinity.

Thus it will be seen how little the virtual resistance, as far as the dynamometer at the generating station is concerned, is increased by increasing the length of the cable. In fact, the virtual resistance tends to a limiting value $\sqrt{\frac{T\rho}{C\pi}}$.

The case of the open circuit differs from the last in that the source which produces the reflected current and potential is in the same phase as the primary source, so that the currents at the middle points neutralise each other. As in such a case no current passes across the middle point, the variation of the potentials along the line is entirely due to the propogation of electricity at the primary source ; the conductor may be cut at the middle point and the end treated as free and perfectly insulated, a point of no current, as in the former case it was a point of no variation in potential.

The *reflected* potential will be

$$\epsilon e^{-\sqrt{\frac{\rho C\pi}{2T}}(2l-x)} \sin \frac{\pi}{T} \left\{ t - \sqrt{\frac{\rho CT}{2\pi}} (2l-x) \right\},$$

and the reflected current, positive towards origin of x,

$$\epsilon \sqrt{\frac{C\pi}{T\rho}} e^{-\sqrt{\frac{\rho C\pi}{2T}}(2l-x)} \sin \frac{\pi}{T} \left\{ t - \sqrt{\frac{\rho CT}{2\pi}} (2l-x) + \frac{T}{4} \right\}$$

Combining the primary and secondary effects, and writing as before $\sqrt{\frac{\rho C\pi}{2T}} = a$, we have for potential at any time and place

$$E = \epsilon e^{-ax} \left\{ 1 + e^{-4a(l-x)} + 2e^{-2a(l-x)} \cos 2a(l-x) \right\}^{\frac{1}{2}} \sin \left(\frac{\pi t}{T} - ax - y \right),$$

where $$\tan y = \frac{e^{-2a(l-x)} \sin 2a(l-x)}{1 + e^{-2a(l-x)} \cos 2a(l-x)},$$

which shows that the phase of the potential is *postponed* by the *finite insulated* conductor, compared with the phase at the corresponding point of an *infinite* conductor.

The current at any place and point of time is given by

$$I = \epsilon \sqrt{\frac{C\pi}{T\rho}} e^{-ax} \left\{ 1 + e^{-4a(l-x)} - 2e^{-2a(l-x)} \cos 2a(l-x) \right\}^{\frac{1}{2}} \sin \left(\frac{\pi t}{T} - ax + \frac{\pi}{4} + z \right),$$

where $$\tan z = \frac{e^{-2a(l-x)} \sin 2a(l-x)}{1 - e^{-2a(l-x)} \cos 2a(l-x)},$$

which shows that the phase of the current is *advanced* by the

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finite insulated conductor, compared with the phase at the corresponding point of an infinite conductor. But in this case also the difference of the phases of E.M.F and current differs at different points of the circuit.

The dynamometer reading for any point will be

$$\epsilon^2 \frac{C\pi}{2T\rho} \cdot e^{-2ax} \left\{ 1 + e^{-4a(l-x)} - 2e^{-2a(l-x)} \cos 2a(l-x) \right\}$$

If we write $\overline{l-x} = d$, and therefore $x = \overline{l-d}$, we have for the dynomometer readings at distance d from the free end

$$\epsilon^2 \frac{C\pi}{2T\rho} \cdot e^{-2a(l-d)} \left\{ 1 + e^{-4ad} - 2e^{-2ad} \cos 2ad \right\}$$

$$= \epsilon^2 \frac{C\pi}{2T\rho} e^{-2al} e^{2ad} \left\{ 1 + e^{-4ad} - 2e^{-2ad} \cos 2ad \right\}$$

$$= \epsilon^2 \frac{C\pi}{2T\rho} e^{-2al} \left\{ e^{2ad} + e^{-2ad} - 2\cos 2ad \right\}$$

Which may be written

$$\epsilon^2 \frac{C\pi}{2T\rho} e^{-2al} \left\{ \cosh 2ad - \cos 2ad \right\}$$

As in the former case, the virtnal resistance B may be found by dividing the maximum value of E by the maximum value of I; whence,

$$B = \sqrt{\frac{T\rho}{C\pi}} \left\{ \frac{1 + e^{-4a(l-x)} + 2e^{-2a(l-x)} \cos 2a(l-x)}{1 + e^{-4a(l-x)} - 2e^{-2a(l-x)} \cos 2a(l-x)} \right\}^{\frac{1}{2}}$$

In this expression put $x = 0$ and (for brevity) $2al = \theta$. Then B becomes

$$\sqrt{\frac{T\rho}{C\pi}} \left\{ \frac{1 + \frac{\theta^4}{\underline{|4}} + \frac{\theta^8}{\underline{|8}} + \ldots\ldots}{\frac{\theta^2}{\underline{|2}} + \frac{\theta^6}{\underline{|6}} + \frac{\theta^{10}}{\underline{|10}} + \ldots} \right\}^{\frac{1}{2}}$$

If $\theta = 0$, *i.e.*, when the length of the conductor l vanishes, the expression in the bracket is infinite. But if θ is infinite, *i.e.*, when the length of the conductor is infinite, the expression in the bracket becomes equal to unity. Thus B diminishes from infinity to $\sqrt{\frac{T\rho}{C\pi}}$ as increases from zero to infinity. Thus, in every case, $\sqrt{\frac{T\rho}{C\pi}}$ is the virtual resistance of an infinitely long cable, whether put to the earth or not.

The expressions for B may be made extremely simple by using the symbols of hyperbolic trigonometry. In the case of the conductor put to earth at distance l from the point of observation, we have

$$B_1 = \sqrt{\frac{T\rho}{C\pi}} \left\{ \frac{\cosh 2al - \cos 2al}{\cosh . 2al + \cos 2al} \right\}^{\frac{1}{2}}$$

and in the case of the conductor having a free end at distance l from the point of observation,

$$B_2 = \sqrt{\frac{T\rho}{C\pi}} \left\{ \frac{\cosh . 2al + \cos 2al}{\cosh . 2al - \cos 2al} \right\}^{\frac{1}{2}}$$

I propose to illustrate by numerical examples and tables the formulæ given in this article, already quite long enough. But the three cases considered have so close a connection with one another that it would have been undesirable to separate them by numerical matters; and the three can moreover be best treated simultaneously.

(To be continued.)

FIRING CARTRIDGES BY ELECTRICITY.—A design for the application of electricity for discharging firearms has just been patented by Mr. T. Page Wood, gunmaker, of Swindon and Bristol. The invention consists of an arrangement of wires through which the current of electricity is passed to the rear of the cartridge. The battery is carried in the butt of the weapon, and the act of pulling the trigger electrically connects the wires with the charge. In connection with this invention Mr. Wood has introduced a patent cartridge.

ON THE DESIGN AND CONSTRUCTION OF DYNAMOS.

BY GISBERT KAPP.

(Continued from page 513, Vol. XIV)

The case of a Gramme ring last considered makes it necessary to distinguish between the useful and useless lines of force. In practice this is inconvenient, as we have no means to determine how many lines are useful and how many are useless. Even if we had an instrument by which we could determine the number of lines passing across the central space of the ring (the dotted lines in Fig. 14), it would hardly be possible to employ such an instrument on an actual machine, because the central space is almost entirely occupied by the spindle and hub or spokes which support the ring. It is therefore more convenient to disregard the useless lines altogether, and to introduce the conception of magnetic density for the purpose of estimating the number of useful lines passing actually along the core. According to this conception every square centimetre of core on the cross section C A carries a certain number, μ, of lines, and the total number of useful lines is found by multiplying this magnetic density μ with the area of cross section. It should be at once remarked that the magnetic density is not uniform throughout the area of the core, but is greatest near the outer periphery. For our purpose, however, we may take an average value for μ, and write

$$Z = 2\mu a b$$

where Z is the total number of useful lines, a the radial depth, and b the length of the core. This method of treating the question has also the further advantage of being equally applicable to drum armatures. We need only increase the radial depth a of the core until the central space has completely vanished to obtain a Gramme ring, which is magnetically and electrically equivalent to a Siemens armature of equal diameter. In this case all the internal wires of the Gramme winding would have to be crowded into the axis of the spindle, that is into a mathematical line. This, of course, is practically impossible, because the wires must have a certain thickness to carry the current, and must therefore occupy a certain space. But the argument still holds good; for whatever the space occupied by the bundle of wires, the current in one-half of the wires must always be in the opposite direction to that in the other half, and since the wires lie close together the effect of all these currents on the magnetic condition of the core is *nil*. Conversely the influence of the magnetism of the pole pieces on this bundle of wires must be *nil*, and the electromotive force of the armature is not increased by these wires. They serve merely as connecting links between the wires on the outer circumference, and if the connections could be made in any other way the armature would give the same electromotive force. This is actually done in the Siemens machine. The connection between the external wires is made across the ends of the drum, and thus the resistance of the armature is less than would be the case were the connection made by means of the internal bundle of wires. It is interesting to compare the Gramme and Siemens armatures with regard to resistance. The total amount of wire wound on a Siemens armature, whose length is b and diameter d, is theoretically

$$n(b + d),$$

though practically somewhat more, on account of the space occupied by the wires where they cross over on the ends. The length of each cross connection is therefore not equal to the straight diameter d, but to the meridian of the curved end surface. As a fair average we may take it that this surface is about midway between a hemisphere and a plane. The meridian of this surface would be about $\frac{d}{2}\left(\frac{\pi}{2} + 1\right)$, or nearly $1{\cdot}3\,d$. The actual length of wire on a Siemens armature having n turns is therefore

$$n(b + 1{\cdot}3\,d).$$

The actual length of wire on a Gramme armature is

$$2n(b + a).$$

The difference between the two is

$$\text{Gramme} - \text{Siemens} = n(b + 2a - 1{\cdot}3\,d).$$

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If this difference be positive the Siemens method is more economical; if the difference be negative, the Gramme method requires less wire. The two are equally good if $b + 2a = 1{\cdot}3\,d$.

Before we can draw any conclusion from this formula, we must make an assumption regarding the proportion between depth of core and its diameter in the Gramme armature. In most modern machines this proportion lies between ·15 and ·20.

Taking ·175 as an average we find

$$b = {\cdot}95\,d$$

as the proportion between diameter and length of an armature at which the Siemens and Gramme methods give equal resistances.

If $b > {\cdot}95\,d$, the Siemens method will give less resistance; if $b < {\cdot}95$, the Gramme method will be preferable.

But to return to our problem of finding the electromotive force created in any of these armatures. If the central space in a Gramme ring be gradually diminished by increasing the radial depth of the core, we approach more and more a Siemens armature; and we reach it if $a = \frac{d}{2}$, the total number of useful lines being in this case

$$Z = \mu\,d\,b.$$

Substituting this value into our formula for $E\,a$, the electromotive force in the armature, we have for a Siemens machine,

$$E\,a = \mu\,d\,b\,N t\,n,$$

and for a Gramme machine,

$$E\,a = \mu\,2a\,b\,N t\,n.$$

It should be remarked that μ is not necessarily equal in both cases; generally speaking it is larger in the Gramme armature. The last formula is applicable to both cylindrical and disc armatures. The character of the armature is determined by the relative values of a and b. In the usual Gramme ring $a < b$, but in disc machines $a > b$. In the equation for $E\,a$, all the quantities are known, or can be obtained from measurements on the machine, except the coefficient μ, which is the number of lines of force passing through one square centimetre of core area at the diameter of commutation.

The aim in designing a dynamo should naturally be to obtain a maximum of electromotive force with a minimum expenditure of material, and at a reasonable speed. From this it follows that μ should be as large as possible. If we were to attempt to raise the E.M.F. by making a and b (the cross-section of the core) large, the whole machine would become too costly and bulky, whilst if we attempted to increase the E.M.F. by a greater number of turns (Nt) on the armature, the resistance of the latter would be too great for economical working. This expedient would also entail the further disadvantage of causing too much sparking at the brushes, as the reader can easily see by referring back to our mechanical model (Fig. 11), which illustrates the effect of self-induction. All these difficulties are overcome, or at least minimised, if the density of lines in the armature core is sufficiently great. In fact the value of μ is a measure for the excellence of the machine.

The above equations for $E\,a$ give the electromotive force in absolute measure. For practical purposes, it is more convenient to employ a formula which gives $E\,a$ directly in volts, and in which the coefficient μ is not a figure of thousands. In this modified form the equation is,

$$E\,a = \frac{\mu\,a\,b\,N t\,n}{1{,}000{,}000},$$

where $E\,a$ is the electromotive force in volts developed in the armature, a the radial depth of the core in inches, b its length in inches, Nt the number of turns of wire on the outer circumference of the armature counted all round, and n the number of revolutions per minute. The coefficient μ varies between 20 and 40 according to the design of the machine and the degree to which the field magnets are excited. Higher values for μ than 40 can be obtained, but at great expense of exciting power. As a fair average, we may take $\mu = 30$ if reckoned over the gross area of the core, including air spaces and insulation between the sub-divisions of the core. If the formula is to be applied to a Siemens or other machine having a drum armature, without any central space free of iron, then a is the radius of the core. The other symbols have the same signification as in the case of a Gramme armature.

In a given machine it is very easy to find μ experimentally. We would work the machine at its proper speed and note the current sent into the outer circuit, and the difference of potential between the two brushes. In the case of a shunt machine, or a compound machine, we would also measure the current used in the shunt coils, or we would calculate it from the electromotive force and the resistance of the shunt coils. Let Cs be the shunt current, c the external current, $E\,b$ the difference of potential at the brushes, and $R\,a$ the resistance of the armature, then the equation evidently obtains

$$E\,a = E\,b + R\,a(C + C\,s).$$

Having thus found $E\,a$, we can determine μ by the formula,

$$\mu = \frac{1{,}000{,}000\,E\,a}{a\,b\,N t\,n}.$$

So far, this is easy enough. But the difficulty is how to determine μ before the machine is actually made and tested—in other words, how to design the machine in order that the magnetic coefficient μ shall have a certain predetermined value.

To treat this question, we must refer back to our analogy between the magnetic and voltaic circuit. It was then pointed out (p. 346, Vol. XIV.) that according to this conception the number of lines produced by a certain exciting power in a wrought-iron electro-magnet is the ratio between that exciting power and the magnetic resistance in the circuit. It is customary to measure exciting power in ampere-turns; as regards magnetic resistance, however, no generally accepted unit does as yet exist. The number of lines created depends not only on the resistance of the circuit, but also on the material of that portion of the core which is directly under the influence of the coils. Remoter parts of the core seem to have only an influence as far as they affect the resistance. To make this clear by an example, imagine we have a horse-shoe magnet of the form shown in Fig. 15, where the length of the yoke is exactly equal to that of both cores.

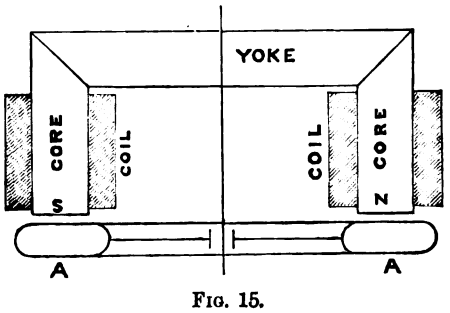

FIG. 15.

A magnet of such proportions could very well be employed in a disc machine, A A being the armature. As far as the magnetic resistance alone is concerned, it will be clearly all the same whether we make the cores of cast-iron and the yoke of wrought-iron, or *vice versâ*, for the lines would have in either case to traverse equal lengths of cast-iron and wrought-iron. Yet experience shows that it is preferable to make the cores of wrought-iron and the yoke of cast-iron. We are thus forced to the conclusion that the total number of lines is not simply ampere-turns divided by magnetic resistance, but that this proportion must be multiplied with some coefficient depending on the material of that part of the core which is immediately under the influence of the coils. What this coefficient is for different qualities of iron the author is unable to say, as he has not made sufficient experiments on this point. An investigation of this kind would be very instructive, and in the hope that some one of his readers might undertake it he would point out how the experiments should be made. Two magnets should be constructed, one with a cast-iron yoke and wrought-iron cores, the other with a wrought-iron yoke and cast-iron cores. In shape these magnets should be exactly alike, so that the same exciting coils can be used for either. To measure the number of lines created by various exciting currents in either

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magnet, an armature, A A, in the shape of a flat Gramme ring should be used. The core of this armature would consist of the usual soft iron wire, but only one coil, or perhaps one turn of copper wire, should be wound round it. The terminals of this coil are to be connected to a delicate galvanometer, and the deflection must be noted whilst the armature is turned one-half revolution, so that the coil is moved from one neutral point to that on the opposite side. If certain precautions are taken, especially with regard to limiting the throw of the galvanometer, the latter is almost exactly proportional to the total number of lines cut by the coil in its transit from one side of the field to the other. In this way it would be possible to determine for different qualities of iron their relative value with regard to the creation of lines of force. The apparatus above described would also serve to show how many lines are created by a simple coil or solenoid without iron core, and how this number is multiplied by the presence of an iron core.

The author has made all his experiments on real dynamos, which could of course not be modified and arranged with the same facility as could a small model. Especially, the question of the relative value of cast iron and wrought iron could not be closely investigated, for it is too expensive to make different combinations of yokes and cores on a large scale. In one case he has, however, determined the difference between cast-iron and wrought-iron magnets. Both were adapted to receive the same armature (from one of the author's own dynamos designed to feed seventy 20-candle lamps), and he found that the cast-iron field gave 80 volts when at the same exciting power the wrought-iron field gave 100 volts. To obtain 100 volts with the cast-iron field the exciting power had to be more than doubled. The armature was a modified Gramme with a smooth core. Had it been provided with external iron projections like the Pacinotti, Bürgin, or Weston, the difference would probably not have been so great. The experiment proved conclusively that cast iron should not be employed for the cores of dynamo magnets, and in establishing our formula for the number of lines we will assume that the cores consist of soft wrought iron.

(To be continued.)

A CONTEMPORARY OF FRANKLIN.

Maximilian Hell, professor of astronomy and director of the Imperial Observatory of the University of Vienna, though better known perhaps for his astronomical researches, was an earnest student of electrical science. Born in 1720, at Chemnitz, in Hungary, where his father was director of the hydraulic machines belonging to the neighbouring mines, he would appear to have been destined for mechanical engineering both by parentage and opportunity. Accordingly we find his genius asserting itself in this direction during his early manhood. Having completed his school education at Neusol, he entered in 1738 into the society of the Jesuits, who in 1740 sent him to the college of Vienna. "At this seminary," we are told, "he studied philosophy for three years, during which time he displayed great mechanical genius, and employed his leisure hours in constructing water clocks, terrestrial and celestial globes, and machines of the like kind. In the years 1744 and 1745 he devoted himself to his favourite pursuit, mathematics, under the care of the celebrated Frœlich [a name not unknown in the electrical annals of the present day], and not only assisted Franz, the astronomer of the Jesuits' observatory, in his astronomical labours, but also in arranging the museum for experimental philosophy." Having gained distinction as a teacher of mathematics at various schools during the next three or four years, and obtained a reputation as a writer of mathematical works, we find him again at Neusol, in 1752; having been elevated to the rank of a priest in the previous year. About this period he began building the Observatory of Tyrnau, in conjunction with the director of the college of that town, Borgias Keri, the degree of doctor and the public professorship of mathematics at Clausenburg being conferred on him as a reward for his indefatigable zeal. He was also entrusted with the care of establishing a new college and an observatory at the latter place, and of providing the necessary philosophical and mathematical instruments, chemical apparatus, and books. Though his time was thus fully occupied he found leisure to study electrical phenomena, and is credited with important discoveries as to the effects of electricity, which corresponded with those of Franklin, Beccaria, and others. Those of our readers who have a good memory for historical facts will remember that it was about this time (1752) that Franklin made his celebrated kite experiments, and though news travelled slowly in those days, it is more than probable that Prof. Hell had heard of them. Unfortunately Hell's experiments were never published, though we are told that some account was given of them in Jaszlinsky's "Natural Philosophy," published at Tyrnau. Whilst at Clausenburg he again devoted himself to writing mathematical works intended more particularly for the use of his pupils, but was interrupted in his labours by being asked to accept the post of astronomer and director of the new observatory then being built at the Vienna University. This was in 1755. From this time until 1767 he appears to have devoted his energies to astronomical work, although the publication of a small work entitled, "An Introduction towards the Useful Employment of Artificial Magnets," shows that he still found time to continue his electrical studies. In the year 1767 Hell was invited by the then King of Denmark (Christian VII.) to observe the transit of Venus, which was predicted for the 3rd June, 1769, from an island in the arctic seas, near Wardoehuus, at the northern end of Europe. This invitation he accepted, setting out on the 28th April, 1768, and arriving at his destination on the 11th of October following. He built an observatory on the island, and in spite of many difficulties and dangers carried out a regular series of meteorological and magnetic observations from December, 1768, to June, 1769, in which latter month he set out on his return to Copenhagen. As the result of his plucky expedition, Hell promulgated a new theory of the aurora borealis, discovered that there was a great declination of the magnetic needle in different longitudes and latitudes, and that in lat. 70°, in which his observatory was situate, it varied continually. His observations were not confined to meteorological, geographical, or electrical matters, but were extended so as to embrace the history, religion, and language of the people amongst whom he had come, as well as the natural history of the district. The transit of Venus was very clearly observed, and the results of the whole expedition were remarkably good. These were communicated to the Academy of Sciences at Copenhagen on Hell's return, and were subsequently published. In 1770 he returned to Vienna, where he set about collecting and arranging the fruits of his journey with the intention of publishing them for the benefit of the scientific under the title of "Expeditio literaria ad Polum Arcticum." As ill fortune would have it, however, this work never appeared, and we are somewhat significantly told, remembering his connection with the Jesuits, "the cause of its suppression is not known." After this Hell appears to have busied himself with his astronomical records, which he kept regularly until his death in March, 1792. We hear no more of his electrical studies, though we are at liberty to conjecture that they were prosecuted with the characteristic vigour of the man. Some day, perhaps, they will be unearthed from the dust of forgetfulness and oblivion, and the electrical world may be astonished to find how much this Jesuit priest really knew about electricity.

THE SOUTH OF ENGLAND TELEPHONE COMPANY.—Notice is given that the first ordinary general meeting of this company will be held on Thursday next, at 1 p.m., at the Cannon-street Hotel, in conformity with the Companies' Acts, 1862-1880.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 15th inst. amounted to £2,734.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 15th May were £2,141, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th May are £3,811, as compared with £3,051 in the corresponding period of 1884. The January receipts, estimated at £5,447, realised £5,391.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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NOTATION AND NOMENCLATURE.

The paper read and discussed at the last meeting of the Society of Telegraph Engineers will probably prove of some historic interest, inasmuch as it has compelled the Council to change their usual attitude of meditation for one of action. Some three or four years ago the suggestion was made to the Council of Telegraph Engineers that a committee should be formed for the purpose of considering the question of Electrical Notation and Nomenclature, but, as is usual in England when an initiative is to be taken, the suggestion was quietly shelved. From time to time since that period the question has been mooted in our columns and in the columns of our contemporary, the *Engineer*. M. Hospitalier, in France, and Messrs. Munro and Jamieson in England, working independently to provide pocket-books for electrical engineers, became tolerably familiar with the chaotic state of electrical notation and nomenclature. M. Hospitalier may claim priority in action, for the formation of the "Commission des Notation Electriques," by the International Society of Electricians, is due almost entirely to his energy and perseverance. This Commission has considered the question, and has drawn up an interim report, which at present is to a certain extent confidential; hence we can only refer to it in somewhat general terms. The question has, we are informed, been considered not only from the standpoint of the requirements of the electricians of France, but from the broader basis of cosmopolitan requirements.

At the meeting of the Telegraph Engineers last week we were told that the Council of that body had agreed to the formation of a committee to report upon the question, and to consult with the French Committee in order that the whole subject might be satisfactorily dealt with—once and for all. Unfortunately we cannot suppose that the French Committee will agree to discuss the question *de novo*; hence it remains simply for the new committee either to accept what has been done, with perhaps a little tinkering for form's sake, or to construct a system of its own. In the latter case we should have before us the rival systems of England and of France, and the universal system would be relegated to the distant future. We cannot help going out of the way to utter another protest at the general policy of the Society of Telegraph Engineers. The scientific position of England does not tolerate being constantly in the second or third rank; but this Society seems to rest satisfied with following and never leading. It should really represent the electrical voice of England, but it does nothing of the kind. In no one single thing does the Society take the rank it should take, and certainly would take if less timorous counsels prevailed. To return to our immedate subject, Mr. Jamieson's paper is admirable as showing how simple it is to pull anything to pieces; but when we consider it as a constructive system in contradistinction to a destructive criticism its value is not so great. The consideration of the question is not at all as simple as it looks. In the first place, it may be asked, are we to assume without discussion that the C.-G.-S. system is acceptable? Of course this is the French system, and it is partly accepted by English scientific writers, although some writers do not accept the system, but prefer the M.-G.-S. system. We have yet to learn, however, which of these systems really commends itself to practical men. Restricting the discussion more closely to the exigencies of electrical science, it will be seen that the existing chaos has grown out of the requirements of telegraphy, and this may form one of the strongest reasons why the developed system should be altogether out of place when used for the requirements of electrical engineering. It may not be to our taste—as pertaining more to the ranks of pure science than to those of applied science—to imagine that the men of theory must of necessity in many things give way to the men of practice; but it is a fact, nevertheless. On the face of it the supposition is only natural that the requirements of electric lighting, for example, are altogether apart from those of aerial or submarine telegraphy. The units used in telegraphy apply to quantities of a very minute nature as compared with those of electric lighting. The construction of dynamos will gradually go out of the hands of the electrician into those of the electro-mechanical engineer, who will suit his own taste and convenience as to the terms he uses; and unless a practical system in accordance with his views is adopted, he will create or import mechanical terms to satisfy his wants. The constructing engineer of the last new ironclad or Atlantic liner is not going to talk about the work developed in ergs, nor will the builders of dynamos in the near future be satisfied to follow the usage developed from telegraphic progress. We already find some makers designating their machines as of so many units, after the fashion of the Board of Trade. The units, however, adopted by the Board of Trade do not fare well in the hands of those who criticised Mr. Jamieson's paper, nor should we imagine that they would fare any better in the hands of a committee.

Should, however, the adoption of the C.-G.-S. system be confirmed, it will be difficult for any committee to differ materially from the conclusions arrived at by the French Committee. We should agree with Mr. Jamieson in using C as a symbol for "current," and not I as suggested by the French Committee; but instead of K for "capacity," we should

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prefer to follow the system adopted in chemical notation and use the symbol Cp., leaving C.P. to indicate "candle-power." There is another practical consideration which has evidently escaped the attention of Mr. Jamieson when arranging his symbols, and this consideration also applies to the suggestions made by Mr. Munro. Those who are best acquainted with the troubles and trials of printing will understand that the multiplication of signs means not only the multiplication of expense in adding to the immense number of symbols already in use, but multiplies the probabilities of error. It is at the present time very difficult indeed, no matter how careful men may be, to get a mass of symbols, mathematical or otherwise, put into type without some very grave errors. The expense attached to this class of work is greatly in excess of that of ordinary printing, and therefore in the construction of any system of notation every effort should be made to introduce as few new symbols as possible, and those introduced should be of as simple a character as possible. It seems to us that the French Committee have not forgotten this point, and if we might venture the suggestion to the Society of Telegraph Engineers as to the formation of its committee, it would be that the names of several mechanical engineers and one or two practical printers be added to the committee, in order that questions which would not present themselves to an ordinary committee might be considered, and a more complete and practical system of notation and nomenclature devised.

CORRESPONDENCE.

ELECTRICAL CONDITION v. RECENT SCIENCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There are one or two points in the letter from "S. E." in your last week's issue that I am afraid are not quite clear to me.

In the first place I should like to know how "S. E." measured the force necessary to extricate the needle of his electrometer after it had been jammed by the sudden rise of potential, and I don't see that, even if he measured that force accurately, he would be able to calculate from it the force necessary to jam the needle.

Would he also kindly explain the method he used for measuring the potential in the case of the gold leaves.—Yours, &c.,

S. E. R.

18th May, 1885.

P. S.—I enclose my card.

ON THE SEAT OF THE ELECTROMOTIVE FORCES IN THE VOLTAIC CELL.*

BY PROFESSOR OLIVER J. LODGE, D.SC.

(Continued from page 13.)

21. To see if the actual behaviour of such cells at all bears out a hypothesis formed on the above plan, I have made some rough experiments on the lines suggested; that is, I passed the same current through different simple cells. There are so many sources of uncertainty and of variation that it would be very difficult to get really definite and reliable results. Thus, for instance, the back E.M.F. will depend considerably upon how long the current has been flowing, and so the readings will differ according to the time they are taken. The metals I used were zinc-zinc, zinc-copper, and zinc-platinum; and it was found necessary to put the cathode-plate in a porous cell to avoid deposition of zinc on it. But it was now difficult to compare the cells easily when arranged in series, because different porous pots had different resistances. I therefore ultimately decided to use the same porous pot and the same anode zinc plate, and to substitute the other plates one after the other, making the current as nearly the same each time as convenient (by adjusting resistance) and allowing for outstanding discrepancies. An amperemeter placed in circuit measured the current, and the voltameter used was a reflecting galvanometer with some 30,000 ohms in its circuit. Its indications were interpreted absolutely by tapping off, at the same time as the cells, the difference of potential between the terminals of an ohm (or $\frac{1}{4}$ or $\frac{1}{8}$ ohm) coil placed in the circuit.

Any two values of the strength of current enabled the internal resistance of the cell to be calculated, provided its E.M.F. remained constant. With low currents it did seem to be fairly constant, and a mean value of the internal resistance r is reckoned from these as $\frac{1}{2}$ ohm.

The area of each plate under the liquid was exactly the same, and measured 3in. by $2\frac{3}{4}$in. Both faces of each plate were exposed, though naturally one face was more active than the other.

The arithmetical reductions are rather long; the results are all that I give. It will be perceived they are anomalous in places, a great deal of this being dependent on whether the reading of E.M.F. was taken soon after a current-change or not. As I said before, the plan of experiment is avowedly rough, though the actual readings were carefully taken; but without understanding more about the circumstances of the case, and what possibilities of variation there are, I do not see how to plan a perfect system of experiment on the subject.

I will first give relative numbers, simply comparing the differences of potential between the terminals of the three cells when the same current is going through each, the resistance of each being the same, viz., $\frac{1}{2}$ ohm; and then I will interpret the observations absolutely, calculating the E.M.F. of the cell under different currents, and seeing what empirical formula will best fit it.

Relative Differences of Potential between the Terminals of three Voltameters of the same Resistance, through each of which the same current is driven by an auxiliary battery. Anode of each cell, zinc; cathode—zinc, copper, and platinum respectively.

Current Flowing through each Cell, in Amperes.	Deflection of Electrometer attached to the Terminals of		
	The Zinc-Zinc Cell.	The Zinc Copper Cell.	The Zinc. Platinum Cell.
·55	-125	+70 to +90	+ 87
·94	-148	+ 26	+ 40
1·88	-486	- 15	+ 50
1·5	-440	+ 15	+110
2·4	-535	- 65	+ 15
2·0	-486	- 8	+ 80
2·4	-626	-140	-100
1·96	-575	- 77	- 30
3·2	-700	-225	-201
2·73	-630	-250	-116
4·2	-800	-347	-335
3·4	-741	-250	-210

In the above table the difference of potential between the terminals is written negative when it opposes the current, and positive when it helps it on.

We will now interpret similar measurements absolutely, reckoning the actual E.M.F. of each cell, and try to fit an empirical formula to it on the plan of those (in Sect. 20) already guessed; assuming $f(C)$ a linear function, for simplicity, until forced to try something more complex. It is quite impossible that $f(C)$ can be a linear function really, but it very likely begins by being so, and only for big currents diverges notably. A hyperbolic tangent function, at a guess, would seem most likely to represent the case properly.

Electromotive Force of a *Zinc-Zinc*, Dilute Sulphuric-Acid, Cell, of Resistance $\frac{1}{2}$ ohm, through which the specified currents are driven by two or three Grove's; each plate exposing 53 square centimetres on each face.

Current, in amperes, C.	Difference of potential between terminals, in volts.	Observed E.M.F. of cell (obtained by adding rC to the preceding column).	E.M.F. calculated from the formula $e = -\frac{1}{2}C$.
·552	- ·37	- ·26	- ·276
·424	- ·34	- ·25	- ·212
·936	- ·44	- ·25	- ·468
·744	- ·40	- ·25	- ·372
1·88	-1·46	-1·08	- ·94
1·5	-1·32	-1·02	- ·75
2·4	-1·61	-1·13	-1·20
1·97	-1·46	-1·07	- ·99
2·4	-1·88	-1·40	-1·20
1·94	-1·80	-1·41	- ·97
3·22	-2·10	-1·46	-1·61
2·68	-1·88	-1·34	-1·34
3·36	-2·22	-1·55	-1·68
4·24	-2·40	-1·55	-2·12

The agreement between the observed and calculated columns is not very bad; and the polarization E.M.F. does not show decided signs of breaking away from the law of simple proportion until a current-strength of 4 amperes is reached—say an intensity of ·04 ampere per square centimetre of total surface.

* Reprinted from the *Phil. Mag.* for May.

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Electromotive Force of a *Zinc-Copper*, Dilute Sulphuric Acid, Cell, of Resistance ½ ohm, through which the specified currents are driven by two or three Grove's; each plate exposing 53 square centimetres on each face. E.M.F. reckoned positive when it helps the current forward, negative when it opposes it.

Current, in amperes, C.	Difference of potential between terminals, in volts.	Observed E.M.F. of cell (obtained by adding r C to the preceding column).	E.M.F. calculated from the formula $e = \cdot8 - \frac{1}{4}$ C.	E.M.F. calculated from the empirical formula $e = \cdot58 - \frac{1}{3}$ C.
·55	+ ·24	+ ·35	+ ·66	+ ·47
·94	+ ·078	+ ·27	+ ·54	+ ·39
·76	+ ·108	+ ·26	+ ·61	+ ·43
1·88	− ·045	+ ·33	+ ·33	+ ·20
1·52	+ ·045	+ ·35	+ ·42	+ ·27
2·4	− ·195	+ ·28	+ ·20	+ ·10
2·0	− ·024	+ ·38	+ ·30	+ ·18
2·4	− ·42	+ ·06	+ ·20	+ ·10
1·98	− ·221	+ ·18	+ ·30	+ ·18
3·22	− ·675	− ·031	− ·05	− ·06
2·75	− ·75	− ·2	− ·11	+ ·03
4·16	− 1·04	− ·21	− ·24	− ·25
3·44	− ·75	− ·06	− ·06	− ·11

Here two alternative formulæ are given; it is a matter of opinion which shows the least divergencies from the column of observed values.

The first is the one most naturally suggested by the theoretical considerations of sect. 20, the ·8 standing for Zn/O − Cu/O, or what is commonly called Zn/Cu.

Electromotive Force of a *Zinc-Platinum* Dilute Sulphuric-Acid, Cell, of Resistance ½ ohm, through which the specified currents are driven by two or three Grove's; each plate exposing 53 square centimetres of surface on either side. E.M.F. reckoned positive when it helps the current on.

Current, in amperes, C.	Difference of potential between terminals, in volts.	Observed E.M.F. of cell (obtained by adding rC to the preceding column).	E.M.F. calculated from the empiriecal formula $e = \cdot4 - \cdot1$ C.	F.M.F. calculated from the formula $e = 1\cdot2 - \frac{1}{3}$ C.
·552	+ ·26	+ ·37	+ ·35	+ 1·02
·44	+ ·30	+ ·39	+ ·36	+ 1·05
·936	+ ·12	+ ·31	+ ·31	+ ·89
·784	+ ·17	+ ·33	+ ·32	+ ·94
1·88	+ ·15	+ ·52	+ ·21	+ ·57
1·52	+ ·33	+ ·63	+ ·25	+ ·69
2·4	+ ·45	+ ·93	+ ·16	+ ·40
2·0	+ ·24	+ ·64	+ ·20	+ ·53
2·4	− ·30	+ ·18	+ ·16	+ ·40
1·96	− ·09	+ ·30	+ ·20	+ ·55
3·22	− ·60	+ ·04	+ ·08	+ ·13
2·72	− ·35	+ ·20	+ ·13	+ ·29
4·16	− 1·0	− ·17	− ·16	− ·19
3·36	− ·63	+ ·04	+ ·06	+ ·08

Here also are two alternative formulæ given, of which the first agrees best with the experimental results. But it is very strange that the E.M.F. of this cell should be so low when the current is feeble: it is scarcely more than that of the copper cell. The only way I see of accounting for the error (if error it be) is that the platinum was put into the liquid after the copper plate, and it was sometimes found coated with a very thin evanescent film of copper when taken out. Theoretical considerations would suggest something more like the second formula as the probable E.M.F., the 1·2 being what is ordinarily called Zn/Pt.

22. I can now continue the quotation of the remainder of the preliminary notes with the certainty that they will be at any rate intelligible. I begin with statements intended to be true for substances of every kind, and then specialise them for the case of metals.

III. *Statements believed by the writer to be true, though not entirely orthodox.*

xii. A substance immersed in any medium tending to act upon it chemically is (unless it is actually attacked) at a different potential to the medium in contact with it; positive if the active element in the medium is electro-positive, negative if the active element is electro-negative.

xiii. The above difference of potential can be calculated approximately from the potential energy of combination between the substance and the medium; the energy being measured by compelling the combination to occur, and observing the heat produced per amount of substance corresponding to one unit of electricity.

xiv. In addition to this contact-force, due to potential chemical action or chemical strain, there is another which is independent of chemical properties but which seems to be greatest for badly conducting solids, and which is in every case superposed upon the former contact-force, the two being observed together and called the Volta effect. Very little is known about this latter force except in the case of metals; and in these it varies with temperature, and is small. In the case of non-metals it is often much larger than the chemical contact-force.*

xv. The total contact-force at any junction can be experimentally determined by measuring the reversible energy developed or absorbed there per unit quantity of electricity conveyed across the junction (practical difficulties, caused by irreversible disturbances, being supposed overcome).†

xvi. In a chain of any substances whatever, the resultant E.M.F. between any two points is equal to the sum of the true contact-forces acting across every section of the chain between the given points (neglecting magnetic or impressed forces).

xvii. In a closed chain the sum of the "Volta forces," measured electrostatically in any (the same) medium, is equal to the sum of the true contact-forces; whether each individual Volta force be equal to each individual true force or not. See section 7.

xviii. Wherever a current flows across a seat of E.M.F., there it must gain or lose energy at a rate numerically equal to the E.M.F. multiplied by the strength of the current.‡

Development of the above and special application to Metals.

xix. A metal is not at the potential of the air touching it, but is always slightly below that potential by an amount roughly proportional to its heat of combustion, and calculable, at any rate approximately, from it. For instance, clean zinc is probably about 1·8 volt below the air, copper about ·8 volt below, and so on. If an ordinary oxodising medium be substituted for "air" in the above statement it makes but little difference.

xx. Two metals put into contact reduce each other instantly to practically the same potential; and consequently the most oxidisable one receives from the other a positive charge, the effect of which can be observed electrostatically.

xxi. There is a slight true contact-force at the junction of two metals which prevents their reduction to *exactly* the same potential; but the outstanding difference is small, and varies with temperature. It can be measured thermoelectrically by the Peltier effect, but in no other known way. It is probably entirely independent of surrounding media, metallic or otherwise.§

xxii. If two metals are in contact, the potential of the medium surrounding them is no longer uniform; if a dielectric it is in a state of strain, if an electrolyte it conveys a current.

xxiii. In the former case the major part of the total difference of potential is related closely to the difference of the potential energies of combination, and is approximately calculable therefrom. In the latter case the total E.M.F. is calculable accurately from the energy of the chemical processes going on, minus or plus the energies concerned in reversible heat-effects.‖

xxiii *a*. "The E.M.F. of an electro-chemical apparatus" whose energy is entirely expended in maintaining a current "is equal to the mechanical equivalent of the chemical action on one electro-chemical equivalent of the substance." (Thomson.)

xxiii *b*. "If the action in a cell consists in part of irreversible processes, such as (1) frictional generation of heat, (2) diffusion of primary or secondary products, (3) any other action which is not reversed with the current, there will be a certain dissipation of energy, and the E.M.F. of the circuit will be less than the loss of intrinsic energy corresponding to the electrolysis of one electro-chemical equivalent. It is only the strictly reversible processes that must be taken into account in calculating the E.M.F. of circuit." (Maxwell: Elementary Electricity, p. 148.)

xxiv. There are two distinct and independent kinds of series in which metals (and possibly all solids) can be placed: one kind depends on the dielectric or electrolytic medium in which the bodies are immersed, the other kind depends on temperature. The one is the real Volta series, but it is the commonly observed Volta series minus the Peltier; the other is the Peltier or thermoelectric series. To reckon up the total E.M.F. of a circuit, we may take differences of numbers from each series and add them together.

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* I here assume, what I suppose is recognised as true, that what is known as frictional generation of electricity is really due to a contact-force between the substances rubbed—a force which is exceedingly great for insulators (see § 19). Davy seems to have held this view, from a note on p. 50 of his Bakerian lecture in 1806, cited before.

† These difficulties are, however, tremendous for most substances except metals. M. Bouty's is the only attempt I know of to examine junction-energy between metals and solutions of their salts, which is the case next in simplicity to metals. Observe that the statement says *energy*, not heat only.

‡ A current gains energy at any junction at which heat is absorbed, or chemical combination permitted, or any other form of energy destroyed, by the passage of the current. The current gains the energy which has in the other form disappeared.

A current loses energy at a point where it causes other forms of energy to make their appearance; *e.g.* generation of heat, decomposition of chemical compounds, &c.

§ To distinguish between Peltier-force and Volta force henceforward it will be best to write Bi/Sb or Zn/Cu for the former, and Zn/Air/Cu or Fe/Water/Pt for the latter. The force electroscopically observed is Air/Zn/Cu/Air, but this involves both; the right way of denoting the Volta effect pure and simple is Zn/Air/Cu.

‖ Such, for instance, as we have been discussing under the head of inconstant or simple voltaic batteries (sects. 19-21). These reversible heat-effects indicate the presence if thermal contact-force, which, wherever they exist, prevent chemical data from giving E.M.F. accurately: they also must be taken into account. We have called them Joule or Bouty effects.

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23. It is necessary to illustrate the meaning of this last statement, No. xxiv. By real "Volta series" I mean such series as we have attempted to calculate from purely chemical data, because they depend on chemical tendencies. By "Peltier or thermoelectric series" I mean those giving a purely physical E.M.F., produced we know not quite how, whose energy-source is not chemical but thermal. We have on the one hand a number of Volta series, each for a special medium, and on the other a table of thermoelectric powers at different temperatures. The latter can be conveniently represented by a number of curves, because temperature varies continuously; Volta series, on the other hand, can hardly be represented geometrically, because the transition from one medium to another is probably *per saltum*; at least, it is not known what is the effect of mixing media, and so passing gradually from one to the next.

We have given several Volta series; and, for the sake of completeness, I will now give some Peltier series for a few substances according to the experiments of Professor Tait at different Centigrade temperatures. Expressing each number as a function of the temperature, we are able to give an infinite number of Peltier series in one table. The range of temperature over which this table may be interpreted is from $-18°$ to $400°$ or so, provided the metals do nor begin to melt. Non-metallic substances have not yet been introduced into such series: much experimental work remains to be done before they can be. The metals used by Tait were not chemically pure.

True Contact E.M.F. or Peltier Series. (Microvolts.)

Metals.	At any Temperature $t°$ C.	At 10° C.	At 100° C.
Iron	$-4760-3{\cdot}94t+{\cdot}0487t^2$	−4795	−4667
Hard Platinum	$-718-{\cdot}54t+{\cdot}0075t^2$	− 722	− 697
Soft Platinum	$+168+3{\cdot}63t+{\cdot}011t^2$	+ 205	+ 641
Magnesium	$-618+{\cdot}36t+{\cdot}0095t^2$	− 613	− 487
German Silver	$+3310+26{\cdot}17t+{\cdot}0512t^2$	+3577	+6439
Cadmium	$-731-14{\cdot}46t-{\cdot}0429t^2$	− 880	−2606
Zinc	$-643+8{\cdot}95t-{\cdot}024t^2$	− 735	−1778
Silver	$-590-6{\cdot}26t-{\cdot}015t^2$	− 654	−1366
Lead	0	0	0
Copper	$-374-3{\cdot}96t-{\cdot}0095t^2$	− 415	− 865
Tin	$+118-1{\cdot}08t-{\cdot}0055t^2$	+ 107	− 45
Aluminium	$+211-{\cdot}31t-{\cdot}0039t^2$	+ 207	+ 141
Palladium	$+1718+16{\cdot}15t+{\cdot}036t^2$	+1883	+3693
Hypothetical* Mercury (Gaugain)	$+1800+4{\cdot}6t-{\cdot}007t^2$	+1845	+2190

* This row of numbers is little better than a guess from some curves given in Wiedemann's *Elektricität*. A more probable deduction from some quite new experiments of C. L. Weber (Wied. *Ann.* November, 1884), gives, for mercury, $1181+5{\cdot}68t+{\cdot}005t^2$. (*Cf.* note to sect. 27.)

To find the E.M.F. of a junction at a specified temperature we have only to subtract the numbers in the above table, inserting the value of the temperature. Thus a junction of zinc and copper at 10° has an E.M.F. of 320 microvolts, acting from copper to zinc; and a unit current sent across such a junction from copper to zinc, or from zinc to copper, absorbs or generates heat at the rate of 320 microwatts, and the current gains or loses energy at the same rate. Clerk-Maxwell says that the force is one microvolt, and that it acts from zinc to copper ('Elementary Electricity,' p. 149, *note*); but he only means, I suppose, that the E.M.F. of a zinc-copper *circuit* with one junction a degree hotter than the other is a microvolt, and is such as to drive the current from zinc to copper across the cooler junction; at least this is true above $-60°$ or $-80°$.*

Hitherto we have supposed the circuit to be all at one temperature; but if different parts are at different temperatures we shall have to use a yet further series, viz., a Thomson series, for the E.M.F. acting in any one substance with a difference of temperature between its ends, or the force acting at a junction of two pieces of the same metal at different temperatures. This series can be deduced from the preceding, using only the coefficient of t^2, and multiplying it by the difference of the squares of the *absolute* temperatures of the two ends of the piece of metal. Such a series then stands thus:—

Thomson Series, or E.M.F. in a metal whose ends differ in temperature. (Microvolts.)

Iron	$\cdot0487\,(t_1-t_2)\left\{274+\frac{1}{2}(t_1+t_2)\right\}$
German silver	$\cdot0512\,(t_1-t_2)\left\{274+\frac{1}{2}(t_1+t_2)\right\}$
Zinc	$-\cdot024\,(t_1-t_2)\left\{274+\frac{1}{2}(t_1+t_2)\right\}$

and so on.

Whether a series of this sort can be made to include any non-metallic conductors also has not yet been discovered. M. Bouty's experiments provisionally indicate the very interesting fact that Sir W. Thomson's general thermodynamic laws of the thermoelectric circuit apply perfectly to circuits which include some electrolytes as well as metals.

Now the meaning of statement No. xxiv. is as follows: Regard zinc and copper in contact as a circuit completed by air or by water as the case may be, and let the temperature be uniform, and say 10°; to reckon up the total E.M.F. we must look in the proper Volta series for Zn/air (or Zn/water), which we find 1·8 say; for Zn/Cu, which we don't find, or find zero; for Cu/air, which we find ·8. Then we must look in the 10° Peltier series for Zn/air or Zn/water, which at present we shall not find there for want of data (possibly we have no right to put them there if we had data); for Zn/Cu, which we find about 320 microvolts; and for Cu/air, which again we don't find. Add them all up with their proper signs, and we have the total E.M.F. of the circuit.

Again, consider the case of a Daniell cell at a given temperature producing a current; we shall have to look in each series for $Zn/ZnSO_4$, for $ZnSO_4/CuSO_4$, for $CuSO_4/Cu$, and for Cu/Zn, and add them all up. It is true that these tables of numbers have practically yet to be made, for at present they include so few substances; but that does not affect the question of the existence and independence of these two kinds of series.

It is, of course, a question how far *all* E.M.F. of contact may be found to depend on chemical tendency. For instance, when bismuth and antimony are put into contact, does the E.M.F. developed measure the alloying affinity of these two metals? When sodium is dropped into mercury, does the heat produced represent the thermoelectric power of a sodium-mercury junction? When metal touches glass, does the tremendous E.M.F. developed represent a tendency of the metal to combine with the glass? These are questions for experiment to decide; but to me it does not seem probable that it will reply in the affirmative.

We know that Sir W. Thomson, and Davy before him, considered the apparent contact-force at the junction of zinc and copper to be due to the chemical affinity between these two metals, and to be measured by the heat of formation of brass; but this we have seen strong reasons for disbelieving. It sounds more probable that the real contact-force at a junction of bismuth and antimony should be due to the chemical affinity between these metals; but perhaps it is no more true. The greater part of a contact-force of this kind is probably due to a physical difference between the metals, such as difference in atomic velocity, and has no close relation to their chemical affinities for each other. It is, however, just possible that *part* of a metallic junction-force is due to chemical tendency between the two metals in contact. For instance, take the case of zinc and copper. There is, I suppose, an undoubted affinity between them, as shown by the formation of brass under proper conditions. [If chemists assume the right to demur to this, on the ground that the two metals mix equally well in any proportions, one can choose any other pair of metals—say, perhaps, copper and tin—for which the statement does not hold.] Now does this affinity result in any E.M.F. between them on making contact? This question, I apprehend, is to be answered by passing a current for a long time across a copper-zinc junction and seeing if any brass does, after a long time, result. Thermopiles show a curious secular deterioration with use, and it may be that some alloying action goes on, though I have never heard of its being noticed. But if no such alloying goes on during the passage of a current, then I should say that, in whatever ways chemical affinity between two metals is able to show itself, it does not show itself as an E.M.F.

Observe, I do not for a moment question the existence of a few hundred microvolts of E.M.F. at a zinc-copper junction. I only ask, is this chemical, or is it physical, or is it a mixture of the two? Statement No. xxiv. is general enough to take into account the possibility of its being a mixture of the two at every kind of junction. It is easy to write one of them zero, if so it turns out.

24. We have been led into a pretty wide discussion of contact-force in general; and, before digressing again on the question of a contact-force-determination of the size of atoms, it may be convenient here to quote the remainder of my preliminary notes, which aim at summarising, in a compact form, the main argument with respect to the immediate subject of discussion, viz., the seat of electromotive force in a voltaic cell, and in ordinary Volta-condenser experiments.

IV. *Brief Summary of the Argument.*

xxv. Wherever a current gains or loses energy, *there* must be a seat of E.M.F; and conversely, wherever there is a seat of E.M.F. a current must lose or gain energy in passing it.*

xxvi. A current gains no appreciable energy in crossing from copper to zinc, hence there is no appreciable E.M.F. there.

xxvii. When a current flows from zinc to acid, the energy of the combination which occurs is by no means accounted for by the heat there

* It is always easy to tell from thermoelectric data which way the force acts at a junction; but it is not always the same way as the current flows, by any means. A current, excited by differences of temperature in a simple metallic circuit, may be urged against the force at *both* junctions. This is the case, for instance, in a copper-iron circuit with one junction above 275° and the other below it by a greater amount. It is customary to say that the current flows across a hot junction from the metal of higher to the metal of lower thermoelectric value; this is not necessarily true. The safe statement is to say that the electromotive force acts from high to low thermoelectric value, at either junction.

* *Note added January* 1885.—My attention has just been called to an article by Mr. Oliver Heaviside in the 'Electrician' of 2nd February, 1884, in which he states views very like those contained in these statements. Had I known of this paper earlier I should of course have mentioned it, but I did not know of it.

Mr. Sprague also, in his book on 'Electricity, its Theory, Sources, and Applications,' on page 331 expresses his belief in much the same sort of way. Although Mr. Sprague is rather too much occupied in tilting against what he considers the absurdities of orthodox and "mathematical" views to work out his own ideas in a very thorough and clear form, there can be no doubt that he has in his own way arrived at very many of the same conclusions as Clerk-Maxwell, though of course in a far less profound and satisfactory manner. He has scarcely received the credit due to him for this, and a cutting review of his book in 'Nature' some years back, though justified in parts by Mr. Sprague's supercilious tone, yet falls into more important errors regarding electrical *facts* than Mr. Sprague himself falls into. See 'Nature,' June 24, 1875, vol. xii. p. 144.

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generated, and the balance is gained by the current ; hence at a zinc-acid junction there must be a considerable E.M.F. (say at a maximum 2·3 volts).

xxviii. A piece of zinc immersed in acid is therefore at a lower potential than the acid, though how much lower it is impossible precisely to say, because no actual chemical action occurs. [If chemical action does occur, it is due to impurities, or at any rate to local currents, and is of the nature of a disturbance.]

xxix. A piece of zinc, half in air and half in water, causes no great difference of potential between the air and the water (Thomson, Clifton, Ayrton and Perry, &c.) ; consequently air must behave much like water.

xxx. If it makes the air slightly positive to the water, as it does (Hankel), it may mean that the potential-energy of combination of air with zinc is slightly greater than that of water, or it may represent a difference in the thermoelectric contact-forces between zinc and air and zinc and water, or it may depend on a contact-force between air and water. [If such a contact-force between air and water exists, it is obviously of great importance in the theory of atmospheric electricity, for the slow sinking of mist-globules through the air would render them electrical.]*

xxxi. Condenser methods of investigating contact-force no more avoid the necessity for unknown contacts than do straightforward electrometer or galvanometer methods ; the circuit is completed by air in the one case and by metal in the other, and the E.M.F. of an air-contact is more hopelessly unknown than that of a metal-contact.

xxxii. All electrostatic determinations of contact-force are really determinations of the sum of at least three such forces, none of which are knowable separately by this means.

xxxiii. The only direct way of investigating contact-force is by the Peltier effect or its analogues. [Maxwell.]

xxxiv. Zinc and copper in contact are oppositely charged, but are not at very different potentials ; they were at different potentials before contact, but the contact has nearly equalised them.

xxxv. The potential of the medium surrounding them is, however, not uniform. If a dielectric, it is in a state of strain ; if an electrolyte, it is conveying a current.

(To be continued.)

ELECTRICAL DEFINITIONS, NOMENCLATURE, AND NOTATION.†

With the rapid progress that has lately been made in electrical science and its applications, there has sprung up a new and fast-increasing class of practical electricians. These, partly from necessity, and partly from well-meant respect, have adopted and applied the old terms and expressions which appeared suitable to their predecessors, as well as coined not a few new ones ; until now their vocabulary is in considerable confusion, and, as all must admit, requires sifting and reform.

Nothing is more tantalising and perplexing than the different modes of expression and symbols used by different authors, and sometimes by the same author, to explain and interpret one and the same thing or result. All this might be avoided if an international system of definitions, nomenclature, and notation was agreed upon and legalised. The rapidity with which the new definitions of the ohm, ampere, and volt (issued and legalised last spring at Paris by the International Congress of Electricians) were universally adopted shows this. These definitions should be still further extended to other electrical units. They should embrace a suitable system of notation, whereby electricians could represent in symbols and letters, terms, expressions, and formulæ of common occurrence, in a similar manner to that adopted by chemists in connection with chemical elements and their combinations. Last session the author promised a communication to the Society on this subject, and, being again reminded by the Secretary of his unfulfilled promise, he now submits a few of the more apparent instances where ambiguity or want of uniformity exists, with suggestions, in the hope that a discussion may follow, and that a Committee of this Society may be formed to consider and draw up a series of definitions, nomenclature, and notation that would be generally acceptable. The proposed Committee might then confer with the French Committee, also with a similar Committee appointed by the British Association, and finally this important question should be referred to the International Congress of Electricians, in order that they may legalise and issue their decisions in a similar manner to that adopted by them in the case of the ohm, the ampere, and the volt. Undoubtedly, if such a course were adopted, most beneficial results would accrue to all concerned.

Only last November, M. Hospitalier brought this subject prominently before the International Society of Electricians at Paris, and strongly advocated an investigation, so that you will no doubt have their support and concurrence.‡

"Sur la proposition du Président, l'assemblée décide qu'une Commission spéciale sera nommée à l'effet de rechercher les meilleures méthodes à adopter pour les notations électriques et de codifier ces notations.

"M. le Président propose, au nom du Bureau, d'appeler à faire partie de la Commission des notations électriques.

"MM. Ed. Becquerel.	MM. H. Becquerel.
,, E. E. Blavier.	,, G. Cabanellas.
,, Marié-Davy.	,, J. Capentier.
,, Tresca.	,, Gauthier-Villars.
,, Maurice Lévy.	,, E. Hospitalier.
,, G. Lippmann.	,, D. Monnier.
,, Félix Lucas.	,, D. Napoli.
,, Mercadier.	,, Pollard.
,, De Meritens.	,, J. Raynaud.

M. V. Williot.

"L'assemblée adopte cette liste à l'unanimité."

Examples.—1. At the very outset students are perplexed by such different terms as "Ordinary* or Static or Frictional or High-tension Electricity." One author will tell his readers or students : "For a long time the name Frictional Electricity was given to a group of phenomena produced by electrical charges. This is an improper expression, because friction is only one means for producing electrical charges."† Another says : "Static Electricity is, however, a misnomer ; it has no existence ; all the phenomena are due to static strains, but there is always a gradual loss called leakage, which is, however, the current due to the actual conductivity of all circuits, and every motion set up by so-called static electricity implies a transfer of energy and action occurring in a field of force set up in the form of strains in the particular inductive circuit in which the motions occur."‡ A third objects to the word "tension" in respect to electricity, and points out that "all the phenomena observable in connection with so-called High-tension Electricity may be produced by electricity drawn from batteries or dynamos if the electromotive force or difference of potential is sufficiently increased." Would not the term "Electro-statics" be more suitable and comprehensive?§

2. The old nomenclature "vitreous" and "resinous," as applied to substances which when rubbed by certain other substances produce opposite electrical properties, and the scholastic one and two fluid theories based upon these effects, should be discarded for the more comprehensive modern theory of electric polarity of molecules or continuous particles, expressed by "positive" and "negative," or by the algebraical signs (+) and (−).

3. "Electrics," "dielectrics," "non-conductors," "insulators," and "isolators" are terms used by different writers to express a condition or behaviour of certain materials with respect to electricity, in contradistinction to the terms "non-electrics" or "conductors," as applied to other materials. The words "electrics," "non-conductors," and "non-electrics" are, strictly speaking, meaningless, because all materials may be termed electrics and all conductors, only differing in degree. The words "isolators" and "isolation" (from the French verb *isoler*, to isolate or separate) should give way to "insulators" and "insulation" as applied to substances which offer a comparatively greater resistance to electricity than semi or good conductors used in connection with the apparatus being referred to at the time.

The term "dielectric"‖ was first used by Faraday on finding that conduction was effected by induction (of polarity from molecule to molecule), and is generally employed by practical electricians when speaking of the inductive capacity of the insulating material surrounding the conductor of leading wires or submarine cables, or that placed between the plates of a condenser. In this sense, viz., of a body transmitting electric induction, or capable of undergoing electric stress, and retaining the stressed condition, it is a very appropriate term to use.

4. The term "accumulator" is the name given in several text-books to apparatus, such as the Leyden jar or condenser, for receiving and retaining quantities of electricity, but has been lately inappropriately applied to secondary batteries, which do not accumulate electricity.

5. "Cascade," as applied to Leyden jars, should give way to "series."

6. "Tension,"¶ "potential," and electromotive force," are terms which, when variously and indiscriminately applied, have given rise to considerable confusion and a great deal of writing in trying to define them. If we consider "tension" as simply the stress put upon the circuit by the electromotive force, and not in the sense that it used to be employed (for example : "Join up a battery or set of condensers for tension"), it might do very well if kept in its place ; but it can easily be dispensed with. "Potential" is a word that has also given great trouble. We find in "Sprague's Electricity"** no less than three pages devoted to an explanation of the different ways in which the words "tension" and "potential" are employed. Clerk Maxwell said : "The theory of electro-statics is greatly simplified by the introduction of this new conception of potential." "As soon as we pass from electrostatics to other deparments of electrical science, we find that the conception of potential is no longer available, except when used in a restricted sense and under carefully-defined conditions." "In other parts of electrical science we have to deal with electromotive force in cases where 'potential' and consequential 'potential difference' are words without meaning." Professor Fleeming Jenkin, in his well-known text-book on electricity and

* *Cf.* lecture on "Dust," Nature, 22nd January, 1885.

† Paper read before the Society of Telegraph Engineers and Electricians on May 14, by Andrew Jamieson, Principal, College of Science and Arts, Glasgow.

‡ Communication faite à la Société internationale des électriciens, le 5 Novembre, 1884, par M. E. Hospitalier sur L'Unité de Définitions, Conventions, Notations, et Symboles Electriques (*vide Electricien*, 15 Décembre, 1884).

* The term used by Faraday. (See "Experimental Researches," by Michael Faraday, p. 82, art. 264.)

† "Electrician's Pocket Book," by E. Hospitalier, p. 5.

‡ "Electricity," second edition, by Sprague, p. 6, art 20.

§ Electricity and Magnetism," by Clerk Maxwell, Vol. I., Part 1.

‖ Faraday's "Experimental Researches," p. 364. "I use the word *dielectric* to express that substance through or across which the electric forces are acting." (See also pp. 537, 538.)

¶ For a good definition of these terms, see "Electricity and Magnetism," by Clerk Maxwell, vol. i., p. 49.

** 1884 edition, pp. 58—62.

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magnetism, devotes twenty-six pages to "potential," and defines "unit difference of potential or electromotive force in electrostatic measure to exist between two points when the unit quantity of electricity in passing from one to the other will do the unit amount of work." "The property of producing a difference of potential may be said to be due to a peculiar force, to which force the name *electromotive force* is given." "The words *electromotive force* and *difference of potential* are used frequently one for the other, but they are not, strictly speaking, identical." "Electromotive force is the more general term of the two, and includes difference of potential as one of its forms." "Potential" might well be reserved for electrostatics, and "electromotive force" for electro-kinematics, or current electricity, and thus prevent confusion. The word "electric-pressure" has come into vogue lately, and strongly appeals to those of a mechanical turn of mind, seeing that the hydraulic simile of "head" or "pressure" is often brought forward to assist in explaining the terms "potential" and "electromotive force."

7. In magnetism we find the same want of uniformity exists. Take the case of a freely-suspended magnetised needle. The pole which turns towards the geographical north is variously called the "austral pole," "north pole," "north-seeking pole," "marked pole," and is painted red by Sir Wm. Thomson, while Sir Wm. George Airy, Professor Guthrie, and others paint it blue. It is sometimes indicated by French makers by the letter A, and by British by the letter N. The pole which turns towards the geographical south is correspondingly called the "boreal pole," "south pole," "south-seeking pole," "non-marked pole," painted blue by Thomson, and red by Airy, Guthrie, and others, and indicated by the letters B or S. Such is the general doubt and diversity in regard to the nomenclature on this subject, that each author on magnetism considers it necessary to state at the outset which term and symbol he intends to apply. If once for all the pole which turns towards the north was termed the "*north* pole," painted red, and indicated by the letter N, and the opposite pole was termed the "*south* pole," painted blue, and indicated by the letter S, much vexation would be saved. The French terms "austral" and "boreal," with letters A and B, should be obliterated. In this way the earth would have a uniformly recognised polarity, which would of course be opposite to that of the magnetised needle—in other words, the true north pole of the earth would be that situated near the geographical south pole.*

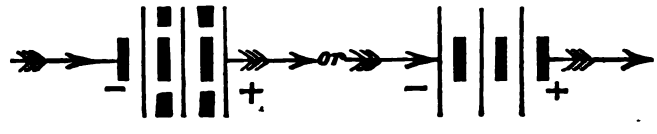
8. Sailors and some writers on the mariner's compass call the angle which the magnetic meridian makes with the geographical meridian the "variation" of the compass, while electricians call it the "declination." Variation is, properly speaking, the hourly, diurnal, annual, or secular changes which occur in the value of the elements of terrestrial magnetism. This leads to great confusion and argument between the electricians and the officers of a telegraph steamer. The declination for each place is marked on the Admiralty charts. Sailors also speak of the "deviation" of a compass, meaning by that the local error due to the resultant of the quadrantal, semicircular, and heeling errors. It would be far better if they simply spoke of the "compass error," or angle which the meridian of their compass-needle makes with the true north and south magnetic bearings. This deviatian or compass error arises from local magnetic influences on board ship. Sir William Thomson's well-known compass, when properly adjusted on board a ship, has no compass error, and therefore the only thing to guard against and correct for in the steering of a ship is the declination of the place where the ship may be at the time of observation. Of course, if the magnetism of the ship changes in the slightest, due to a change of cargo or position thereof (if of iron or steel), or due to buffeting the waves for some time on one course, a slight error will creep in, but the compass can be soon adjusted to the new condition of affairs, and the officers have therefore seldom to think of or even speak of "deviation" or compass "error."

9. When we come to electricity generated by batteries, we find the expressions "galvanism," "voltaic electricity," "dynamic electricity," "electro-kinetics," "current electricity,"† &c., according to the fancy of the writer or speaker. Surely one name might suffice; and certainly the older terms "galvanism" and "voltaic electricity" might well be left to the past. The simple term "current electricity" seems to commend itself, as most of the effects in connection with this branch of the subject have reference to electricity as if it was in motion or distributing itself over a conductor.

10. "Density of current" and "intensity of current" often cause great confusion. "Density of current" should only be used in the case of electrolysis or electro-deposition of metals. Here it means the amperes per unit of surface of the cathode. In electro-statics "surface density" or "electric density" means the quantity per unit area of surface. "Intensity" was used at one time in the same sense as "electromotive force" is now, and therefore not so much out of place there; but several writers, notably Prof. Silvanus Thompson, have thought fit to borrow the French term "*intensité de courant*" wholesale, instead of a translation thereof, and symbolise it by the letter I. The literal translation of the French word *intensité* being strength or amount, therefore the expression "current strength," or simply "current," symbolised by C, is far preferable, for it conveys the correct meaning of the quantity in a given time. With a little pressure, French electricians would no doubt agree to the symbol C instead of I, to promote uniformity. Then I might be reserved for intensity of magnetism, where it suits very well.

11. "Positive electrode," "(+) terminal," "zincode," "anode," "positive pole," and "negative plate," severally used by different writers to designate that end of a cell, battery, or pile where the current leaves, and "negative electrode," "(−) terminal," "platinode," "kathode" or "cathode," "negative pole," "chlorous pole," "positive plate," where the current returns to or enters the same, requires revising and simplifying, more especially when we consider that the end plates of a battery are of opposite sign to their electrodes or terminals, and that the nomenclature is still further complicated when we come to consider secondary batteries or electrolysis by the terms "anion," "kation" or "cation," and "ions." Take, for example, the definition given by Sprague* of "anode:"—"The positive electrode or pole of a battery; the wire or plate connected to the copper or other negative element of the battery; the plate which leads the + current into a solution to be decomposed, and at which are set free the oxygen, acid radicals and all—ions (anions). In electro-metallurgy it is usually formed of the metal to be deposited, in which case it is called the soluble anode or pole."†

12. Again, we have the two different ways of graphically representing a battery according to the whim or fancy of the writer. Practical submarine



electricians were the first to use this very neat and handy way of representing a battery and its poles, and always adopted the former method, with the long thin vertical line for the plate where the current leaves, and the thick short line for the plate where the current returns to the battery. Why should this have been departed from? It is a mere arbitrary arrangement, but, being a most convenient symbol, it should be used in a uniform manner. Mr. John Munro proposes that the symbol for a secondary battery should be a modification of this, viz.,

the current outside the cell proceeding from the long line to the short one.

13. "Parallel circuit," "multiple arc," "loop circuit," "in loop," "derived circuit," "shunt circuit," are all expressions to signify pretty much the same thing, where one expression, "shunt circuit," would do.

14. "Polarisatian" is a term used in many different senses—for example, the polarisation of battery plates, molecular polarisation due to electrification or magnetisation, polarisation of light due to magnetism, &c., as in Dr. Kerr's experiments. Some reform is required here.

15. Coming to telegraphy, telephony, and electric lighting, we find, as M. Hospitalier points out, "the words generator, receiver, transmitter, and motor are mixed up by different inventors, sometimes through ignorance, sometimes willingly." "A generator is an apparatus which, receiving energy of a certain nature, produces an energy of another nature, and it borrows its name from the nature of the energy which it generates. A receiver is an apparatus analogous to the generator but it borrows its name from the energy which it receives." "A given apparatus is at once a generator and receiver—for example, an electric motor is a generator of mechanical energy and a receiver of electrical energy." "The name transmitter ought to be reserved for an apparatus which, receiving an energy of a certain kind, produces or brings into play an energy of the same kind or of the same form." For example, a relay on a telegraph system, or induction coils as used on a trunk telephone line with several subscribers' lines at each end, or in electric lighting on the Gaulard and Gibbs' system, lately tried in London. Professor Silvanus Thompson uses the phrase "Dynamo-Electric Machinery" in the most general etymological sense of the term, as meaning machinery for converting the energy of mechanical motion into the energy of electrical currents, or *vice versâ*, excepting such induction machines as Holtz, Voss, &c. He thinks this reduces the ambiguity to a minimum, and leaves the word "motor" to be applied, if desired, to the steam-engine, water-wheel, &c., from which the mechanical motion is derived. The terms "magneto-electric machine," as applied to a dynamo fitted with permanent field magnets, and "electro-magnetic machine" to a series, separately-excited, shunt, or compound-wound dynamo (generator or receiver), are very handy expressions, and should not be discarded.

16. We have dealt hitherto chiefly with definitions and nomenclature, and have given a few examples; others will occur to every member present. We now come to abbreviations and notation with symbols. The want of uniformity here, and the need for systematising is still more obvious, but perhaps more difficult to accomplish. Everyone admits the great advantage in being able to write down the symbols for chemical

* Sir W. Thomson calls the magnetic pole of the earth, situated near the geographical north, the "north pole," and the end of the magnetised needle which points towards it, the "*true south pole*" of the needle, and paints it red.

† See Ferguson's "Electricity," second edition, by Professor Blyth, p. 164. The term "electro-kinematics" has been used by Clerk Maxwell to cover a large part of this subject, such as "electric current," "conduction," "resistance," "electromotive force," "electrolysis," &c. (See "Electricity and Magnetism," by Clerk Maxwell, vol. i., part 2.)

* Sprague's "Electricity," 1884 edition, p. 624.

† See Faraday's "Experimental Researches," articles 661 to 667, on *Definitions of New Terms*, where he very clearly points out the meaning he attaches to the words "electrode," "anode," "cathode," "ions," "anion," "cation," etc.

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elements and their actions and reactions one with the other in the form of simple equations, which anyone may comprehend who knows the subject, without a detailed description of what each letter or symbol stands for. Electricians should not rest satisfied until they are supplied with a similar universally-accepted notation, whereby electrical phenomena and actions may be similarly treated. The author submits a sample of what he considers would be useful in this respect. Many of them are taken from Munro and Jamieson's "Pocket-book of Electrical Formulæ," where an effort was made to use the same notation and abbreviations throughout, except in such cases as that of quoting direct from some other author.

It will be observed in this list that in most cases the first English or Greek letter of the word has been used. Those relating to the metric system have been copied from the French edition of Hospitalier's "Electrician's Pocket-book," which are no doubt copied from the list decided upon by the International Commission on the Metre, with a few omissions and additions by the author.

The Greek letters π, μ, ϵ are universally adopted—π for the ratio of the circumference of a circle to its diameter, μ for the coefficient of friction, and ϵ for the base of Naperian logarithms.

Metric Abbreviations.

m.	for	metre.
cm.	,,	centimetre.
mm.	,,	millimetre.
m.q.	,,	metre-square.
m.c.	,,	metre-cube.
c.q.	,,	centimetre-square.
c.c.	,,	centimetre-cube.
gm.	,,	gramme.
mg.	,,	milligrammæ.
k.g.	,,	kilogramme.
kgm.	,,	kilogrammetre.
&c.		&c.
temp.	,,	temperature.
res.	,,	resistance.
g.d.	,,	gramme-degree.
kg.d.	,,	kilogramme-degree.

Electrical Abbreviations, Notation, and Symbols.

When a capital letter is used for the symbol, then small capitals or italics with suffixes, 1, 2, 3, &c., may be used for parts making up a whole. For example—L for length, L_1, L_2, L_3, &c., or l_1, l_2, l_3, for different lengths, or parts of L.

Fundamental and Derived Mechanical Units.

L	for	Length.
M	,,	Mass.
T	,,	Time.
V or v	,,	Velocity.
A or a	,,	Acceleration.
F	,,	Force.
δ	,,	dyne; *e.g.*, 10 δ = 10 dynes.
W	,,	Work.
w	,,	weight.
ft. lb.	,,	foot pound.
H.P. or HP	,,	Horse-power.
I.H.P.	,,	Indicated Horse-power.
B.H.P.	,,	Brake Horse-power.

Other Common Symbols allied to Mechanical Work.

S	for	Speed or Stress.
D or d	,,	Diameter.
r	,,	radius.
ω	,,	angular velocity = $2\pi n$ in radians per second.
g	,,	acceleration due to gravity.
N or n_1 n_2, &c.	,,	number of revolutions.
$-^s$	,,	second; *e.g.*, 3^{hr} 5^m 10^s = 3 hours 5 minutes 10 seconds.
$\tau_1\tau_2\tau_3$, &c.	,,	temperatures, absolute.
or $t_1°t_2°t_3°$, &c.	,, ,,	common.

Practical Electric Currents.

The astronomical method of putting the small letters above the line of the figures, as in the case of the example 3^{hr} 5^m 10^s (3 hours 5 minutes 10 seconds), has not been followed in the following examples, as mathematicians object to the system, the letters appearing as if they were powers. Neither will they readily agree to suffixes, as suffixes have been already adopted by them to distinguish between things of the same kind. The author has therefore written the distinguishing letters on a level with the figures: for example, 10ω stands for 10 ohms (the methods 10^ω and 10_ω being both objectionable).

C.G.S.	for	centimetre, gramme, second.
R	,,	Resistance.
ρ	,,	specific resistance.
ω	,,	ohm; *e.g.*, $10\omega = 10$ ohms.
Ω	,,	megohm; *e.g.*, 10Ω = 10 megohms.
C	,,	Current.
A	,,	amperes; *e.g.*, 10A = 10 amperes.
a	,,	milliamperes; *e.g.*, $10a$ = 10 milliamperes.
E	for	Electromotive force or E.M.F.
v	,,	Volts; *e.g.*, 10v = 10 volts.
K	,,	Capacity.
σ	,,	specific inductive capacity.
Φ	,,	farads; *e.g.*; 10Φ = 10 farads.
ϕ	,,	microfarads; *e.g.*, 10ϕ = 10 microfarads.
Q	,,	Quantity (coulombs).
P	,,	Power.
WP	,,	Watts or Watt power.*
W	,,	Work in Joules.
H	,,	Heat in ,,
J	,,	Joule's equivalent = 42×10^6 ergs, or work spent on ·2405 gm. of H_2O raised by 1° cent.

$$C = \frac{E}{R} \text{ (Ohm's law).}$$

$$E \times C = C^2 R = \frac{E^2}{R} = WP \text{ (Watt powers).}$$

$$ECT = C^2RT = \frac{E^2T}{R} = EQ = W \text{ (Joules).}$$

$$\frac{ECT}{J} = \frac{CRT}{J} = \frac{E^2T}{JR} = \frac{EQ}{J} = \frac{W}{J}$$

$= W \times \cdot2405 =$ g.d. or gramme degrees.

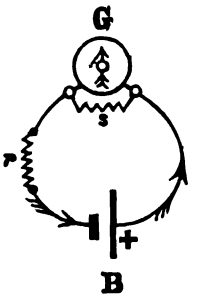
z = Electro-chemical equivalent.

Magnetism.

N	For	North pole of a magnet, painted red.
S	,,	South ,, ,, painted blue.
m	,,	magnet strength (of pole) or quantity of magnetism.
l	,,	distance between the poles of a magnet.
M or ml	,,	moment of a magnet.
$\mathfrak{F}$ or I	,,	intensity of magnetisation.
s	,,	cross section of a magnet.
mp	,,	magnetic potential.
μ	,,	magnetic permeability.
κ	,,	magnetic susceptibility.
H	,,	horizontal intensity of terrestrial magnetism.
θ	,,	angle of deflection.
d_1 d_2 d_3	,,	divisions deflection, as in mirror galvanometer.
r	,,	radius (mean) of a coil or solenoid.
n	,,	number of anything; *e.g.*, turns of wire in a coil o galvanometer.

Take Tangent Galvanometer Formulæ, as an example to illustrate the above:

$$\text{Current, } C = H \frac{r}{2\pi n} \cdot \tan\theta.$$

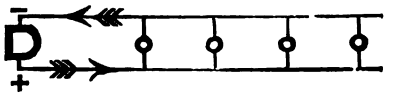


G	for	Galvanometer or galv. res.
s	,,	shunt res. for galvanometer
r	,,	resistance coils
B	,,	Battery or battery res.

$$\therefore R = B + \frac{G S^1}{G + S} + r\dagger$$

Dynamo Circuits Contractions.

Example:



D	for	Dynamo.
T+	,,	Terminal positive.
T−	,,	Terminal negative.
E.M.	,,	Electro-magnet.
or F.M.	,,	Field Magnet.
c.p.	,,	candle-power of a lamp.
A.M.	,,	Ampere-meter.
V.M.	,,	Volt-meter.
S.W.G.	,,	Standard wire gauge.

* By adopting the term "Watt power," there can be no doubt what a Watt means.

† See Munro and Jamieson's "Electrical Pocket-book," p. 65.

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For use in Formulæ.

R_a R_m R_e for Resistance of armature, magnets, and external circuit respectively.

C_a C_m C_e ,, Current in armature, magnets, and external circuit respectively.

L_s ,, coefficient of self-induction.

L_m ,, coefficient of mutual induction.

In the above notation the first letter of the most important words has been used wherever it was found practicable to do so, and the recurrence of the same letter under similar circumstances avoided as much as possible. In cases where no ambiguity can occur, such as H for the heat in Joules, and H for the horizontal intensity of the terrestrial magnetism; m for metre, and m for magnetic strength of pole; V for velocity, and v for volts, it will be observed that the same letters appear in each case.

A discussion followed the reading of the above paper, M. HOSPITALIER, who had come from Paris for the express purpose, leading off with a series of sharp criticisms on Mr. Jamieson's proposals. M. Hospitalier stated that the committee in Paris had already made some progress in devising a scheme of notation and nomenclature such as might form the basis of an international system. Nothing of the kind could be expected of Mr. Jamieson's scheme, which proceeded on no definite principles, and was often contradictory, arbitrary, and hard to remember. Prof. FORBES, Prof. AYRTON, and others followed, their general verdict being unfavourable to Mr. Jamieson's paper. The president, Mr. SPAGNOLETTI, announced that the society had had under its consideration the desirability of arriving at some international understanding on this subject, and had that evening decided to form a committee for its investigation. The committee in the first instance would be a broad one, and not confined to members of the society.

PHILADELPHIA EXHIBITION.

(Concluded from page 380, Vol. XIV.)

THE DELANY CABLE.

("C." of the Section's Classification.)

This cable may comprise any number of conductors desired, and of any size required. When a single conductor is used, a bare or cotton-covered wire, insulated in any of the usual ways, is threaded through small discs or buttons of vitreous material, such as porcelain or glass, so that the conductor throughout its entire length is covered by the incombustible buttons which are about half an inch in length and one-eighth of an inch in thickness. The conductor thus surrounded is passed through a compound of insulating material and through a lead press machine, which encloses the whole in a lead covering or pipe, so that, when finished, the cable or conductor is first enclosed in a braided covering saturated with an insulating compound, then surrounded by the incombustible discs or buttons, again covered with an insulating compound, which is forced in hot as the lead pipe is formed around it. The latter filling occupies all the interstices and space between the conductor and the vitreous buttons and between the buttons and the pipe, thus leaving no air spaces, and thereby preventing condensation of moisture. The incombustible material separating the conductor from the pipe renders the transmission of the most powerful currents absolutely safe, since under no circumstances can the conductor come in electrical contact with the pipe. Should the conductor become heated the soluble insulating compound would be united more firmly, closing up any cracks that might have occurred from low temperature or contraction.

When a series of conductors are used they are all threaded through separate holes in the same disc or button, and thus mechanically separated from each other, and from the pipe in which they are enclosed.

This cable is practically indestructible, as its durability is only limited to that of the enclosing pipe, which may be of lead or iron. When lead is used the cable may be constructed in lengths of one-quarter or half a mile without splicing, and coiled on a reel, the vitreous discs admitting of flexing to any extent necessary,

The conductors cannot become crossed, nor can they be grounded so long as the enclosing pipe remains intact. As the lead pipe is formed around the cable in a molten state, there is no seam, weld, or joint throughout the entire length in each section.

All danger from fire in buildings is obviated. Rats cannot destroy the insulation, and the cable may be laid in chimneys, ventilation or heating flues, or placed in the walls like gas or water pipes, with perfect security against interruption or damage, or the necessity for tearing out the walls for repairs of any kind.

Three tests of this cable were made at the International Electrical Exhibition, for the purpose of ascertaining the effect of powerful currents on the insulation. These tests were made under the direction of Capt. de Wolski, Chairman of the Committee on Underground Conductors. The first consisted of placing a piece of cable about five feet in length so as to short-circuit the Hochhausen electro-plating dynamo machine. This conductor, a single one, insulated as described in the beginning, was No. 4 Birmingham gauge copper wire. The dynamo machine had an electromotive force of two and one-half volts. A current of 600 amperes was passed through the cable for 20 minutes. The conductor was made red hot, but the insulation was uninjured, the melting of the filling-in compound being the only result of the experiment.

The second test was similar to the first, with this difference in the current—800 amperes were sent through the cable for 20 minutes. The wire became so hot that the vitreous discs surrounding it melted the lead covering, leaving the insulation uninjured.

The third test was with the conductor inclosed in an iron instead of lead covering. When sufficient current could not be passed through the conductor to cause any effect other than the melting of the filling compound and charring of the braided covering on the wire, the conductor was perfectly secure in its insulated separation from the pipe and consequently free from all danger.

This single conductor, insulated and inclosed as described, ready for use in the ground or elsewhere, can be furnished for 22 cents per foot. Six separate conductors of No. 16 copper wire, for telegraph or telephone use, and covered in a like manner, will cost the same amount.

INVENTORS' INSTITUTE.

At a meeting of this Institute on Monday evening, Mr. C. E. Spagnoletti in the Chair, a paper "On Electric Tramcars" was read by Mr. A. Reckenzaun. The author said that whilst a single electric tramcar only existed in this country, a paper on the subject might be thought premature. This solitary example is, however, the latest and only practical form; and the Institute has the privilege before other societies of judging of the merits of an invention, as an invention, apart from commercial aspects. After a comparison of horse, steam and compressed air traction with electrical traction, the difference of the electric tramcars from electric tramways and railways was pointed out to be that, whereas in electric tramways the energy is conveyed from the generating station to the rails or other conductor communicating with the motor which turns the car wheels, the electric car carries its own energy within itself, and is quite independent of external influence, and the car can travel over any road or rail for whatever system, ordinary or specially designed. The original Faure battery has never been of practical use, and very substantial improvement had to be made at enormous expense to bring the secondary battery to a commercial value. The Electrical Power Storage Company having acquired the patents of Sellon, Swan, and Volckmar in addition to Faure's, have step by step improved the mechanical details of the storage batteries, until they have arrived at a thoroughly practical article; but the prejudices created in the public mind by the early failures are now encountered and have to be overcome. The cell for the tramcar is contained in a lead-lined strong teak box. In it are placed 21 lead plates, weighing together 26lb., including terminals and fittings. Sixty such cells, weighing one ton and a quarter, are required to propel a car with 46 passengers for about two hours over a road with ordinary gradients, curves, and 60 stoppages per hour. A diagram was shown representing the car which has been running at Millwall and Battersea. The electric motor has to convert the electric current into mechanical power. For tramcar propulsion, it is absolutely necessary that the motor should have high efficiency, and at the same time be of small dimensions and light weight. The author's machine has these qualifications. For the car there are two motors, each capable of working up to nearly nine horse-power, and weighing 420lb. Each motor is carried separately upon a small bogie, in such a way that each bogie forms a small locomotive engine upon which the car rests. One axle of each bogie is a driving axle; thus are actuated four small driving wheels. The speed of the motors is high, about 1,000 revolutions per minute when the car is running at seven miles an hour. Thus it is necessary to introduce reducing gear between the motor shaft and the driving axle. The gearing employed is a worm on each motor shaft, and worm-wheels on the driving axles, giving a ratio of about one to twelve. This worm-gearing is cased in, and the wheels work in oil, the lubrication being perfect. The variation of speed and power is obtained by means of a compound switch, which arranges the motor circuits so that the machines shall work in series, in parallel or singly; thus the resistance of the circuit being varied, the power and speed vary accordingly; when a greater range of speed is desirable the motor circuits are still further divided by arranging the field magnet wires apart from the armatures. This obviates cumbersome gearing which would add to the weight and the expense, increasing first cost and the maintenance as well.

Brake power, both mechanical and electrical, is efficiently applied The most economical steam tramway locomotives burn from nine to eleven pounds of coal per mile. The coal for charging the electric tramcar batteries amounts to four pounds per indicated horse-power. Reckoning the coal at eighteen shillings per ton the fuel per car mile would be less than one penny.

An interesting discussion followed, in which Prof. Geo. Forbes, Mr. Traill, Mr. Shoolbred, Mr. Drake, and others took part, the improvements made by Mr. Reckenzaun being thoroughly recognised.

LEGAL.

The Duplex Telegraph System.

Yesterday the House of Lords gave judgment in the appeal of the Direct United States Cable Company *v.* Muirhead and others. The question in the case was as to whether the Cable Company should pay a royalty of £2,000 per annum under an agreement, they having ceased to use it, owing to the telegraph cable having got into such a state that the duplex system could not be applied. It appeared that the patentees of the duplex system, Messrs. Muirhead, entered into an agreement with the Direct Cable Company to receive £2,000 per annum as royalty on the duplex system of telegraphy "operating satisfactorily" on the line of the company. The Direct Company had only one line, but it was contemplated that there should be four lines, and Messrs. Muirhead were to receive something additional on its being applied to the other lines. In consequence, however, of a former arrangement the Direct Company had the advan-

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tage of sending over another line, and so the simplex system was continued. The line, too, of the Direct Company had got into a state unfitted for the application of the duplex system. The case originally went before Baron Huddleston, and then to the Court of Appeal, who decided against the Direct Company, who now appealed to the House of Lords. Their lordships present were the Lord Chancellor, and Lords Blackburn, Watson, and Fitzgerald.

The Solicitor-General for Scotland and Mr. W. A. Hunter appeared for the Direct United States Company; and Mr. Webster, Q.C., and Mr. Moulton for Messrs. Muirhead.

It was contended for the appellants that, though the duplex system had operated satisfactorily for five years, they were, when the line got into such a state that it could not be applied, entitled to cease the payment of the royalty.

For the respondents it was argued that the whole scope of the agreement showed that what was contemplated was that, as soon as the duplex system was proved to be successful as a system then the respondents were bound to use it and pay the royalty.

The LORD CHANCELLOR in giving judgment said that the decision of the Court below ought to be affirmed. The recital of the agreement, after mentioning that the Direct Company were the owners of a certain line of telegraph cable, proceeded thus: "Whereas the company have proposed to the patentees to apply to their cables the system of duplex telegraphy of the patentees." Now, that application of the system to the company's cables was the object of the entire agreement. The first Article said that "the patentees grant to the company a license to use the inventions in question, so far as they regard the duplex working of telegraphs, and any improvements in and upon or in connection with all or any cables or lines connected with the telegraph cable which they do possess." That was that they purchased a license to use these cables and telegraphs; and it appeared to him that the company were responsible for providing the cables and maintaining the mechanism which they were to lay down necessary for working the duplex telegraph invention. If they did not provide cables of the proper kind, to be judged by reasonable and skilful men, then they would not carry out that part of the agreement which depended upon them. The company must therefore provide two things: cables, to which the system of duplex telegraphy was to be applied, and the mechanism of the duplex telegraphy itself; and they should not only provide these things, but maintain them in a proper state to enable them to get the benefit which they stipulated for from the use of the invention; and he should have thought, independently of any evidence almost, that it was essentially involved in the idea of cables that there should be a proper continuity for the purpose which both parties had in view. He could not conceive how the rights of the patentees were to be taken away merely because the company did not choose to do that which it was incumbent upon them and not upon the patentees to do. By the 11th Article the patentees were in effect to assist to bring into original operation their duplex system on any of the company's cables when required on certain terms. The patentees had done that some years ago. Then the 2nd Article said that as long as the license was in force "the patentees shall and will render to the company, their successors, and assigns, all instructions, advice, and assistance to enable the license to be used to the utmost advantage, at the expense of the company." It was not alleged in this case that the patentees had not complied with this term of the agreement, and everything that the patentees were to do had been fully and completely done. Then the 3rd Article was the clause upon which the question turned. It provided for the consideration of the license—the money payment. That money payment was to commence and to be payable from the date when the patentees "shall have supplied their duplex system to the company's line, and shall be considered as accruing and due from day to day, and apportion it accordingly; and that payment so commencing is to continue during the continuance of the license, and whilst the duplex system of the patentees shall operate satisfactorily, subject as hereinafter provided." Now the first thing to observe was that it was not said, "whilst the mechanism laid down for this duplex system is actually connected with the cable in its actual state for the time shall operate satisfactorily," but "whilst the duplex system of the patentees shall operate satisfactorily." The system was a perfectly different thing from the mechanism which the company and not the patentees laid down and had to keep in order for the purpose of using it, and though no doubt it was involved in the idea of the words "operating satisfactorily" that it should be applied to the company's cables, yet, on the other hand, that condition was satisfied if the operation of the system was satisfactory, and it carefully abstained from making that dependent upon what he might term the accidental condition either of the mechanism for the use of the system or of the cable to which it was to be applied, and for both these the company and not the patentees were responsible. If these words stood alone he should infer that if the fault was not in the system, but in the manner in which the company thought proper to use or not to use it, that the payment was not to stop merely because of those words, "whilst the duplex system shall operate satisfactorily." The whole context of the agreement showed that the payment was not to stop in that event. There were certain stipulations as to when the payment was to be suspended. Article 6 showed that the mere voluntary non-user of the invention on the ground that something else might be more for their commercial advantage was not to be a thing which in itself would suspend the payment, or to which the words, "whilst the duplex system of the patentees shall operate satisfactorily," could be applied, because Clause 6 provided, in the case of any better invention of the same kind recommending itself to the company, that certain things were to be done which might or might not terminate in relieving the company from liability. They first must give notice; then they must in substance give the patentees the opportunity of producing the same effect in as advantageous a manner, and if they did not then the company might be relieved from the payment, therefore making it most clear that if the thing did not operate satisfactorily, merely because the company did not choose to let it operate at all, even for reasons which turned upon their commercial advantage and benefit, that the payment was nevertheless to go on. As to Article 5, he did not think it necessary to go into any question as to the precise event, but taking it that if in a certain manner there was a total interruption of communication of the company's cable between London and New York, then the payment was to cease during the period of interruption. Why was that put in? He should say because, if it had not been put in, and if the patentees and their system had not been in fault, then the liability in the view of both parties would have continued. But if the liability had continued in the case of total interruption, then there was nothing for which the royalty could be obtained, and the fact of there being no similar provision made for a partial interruption, the inference was that it was to go on. Now, what were the actual facts of the case? They were these. A certain amount of continuity and insulation was required for the proper operation of that kind of cable to which this invention was to be applied. It was admitted that there were such serious faults—that there was such a serious breach of continuity and insulation in the case of this cable in the deep sea, that some times there were interruptions of variable duration and importance continually occurring, and that it did not work properly even as a cable for what was called the simplex system. It was capable of transmitting the messages, but not with the rapidity, or certainty, or clearness which it ought to do if in proper order. It was confessedly out of proper order, and he should say out of that sort of order which everybody must be considered to have had in view when the application of this simplex system was made. Who was responsible? Of course the company, because it did not suit them to go to a large expenditure for the purpose of putting that right, the patentees being in no fault whatever, and their system having operated for five years quite satisfactorily until this fault in the company's cables took place, and that being a fault which the patentee did not profess by his patent to be able to remedy. It was agreed by both sides that the duplex system was inapplicable to a fault of this magnitude, and that being the case, it appeared to him that within the true and natural meaning of the contract, and according to good faith, the event had not arisen in which the company was entitled to say that the system of the patentees was not "operating satisfactorily." He therefore agreed with the judgment of the Court below, and he advised their lordships to dismiss the appeal, with costs.

Lord BLACKBURN said he perfectly agreed with the judgment of the Lord Chancellor. The words they were to construe were that the company were only to pay whilst the duplex system of the patentees "shall operate satisfactorily." The parties probably had in their minds what James Watt said of some inventions, that they were mere toy models, and they might consider that if it operated satisfactorily then they would be willing to pay £2,000 a year. They began working in April, 1867, and it had worked satisfactorily for five years; and he could not think that the system had ceased to operate satisfactorily merely because the cable got so far out of order that it no longer operated satisfactorily upon the cable. But he would go further, and say that if the system worked satisfactorily, and if the line were injured and it would cost more to bring it into a state of repair to use the duplex system, still the company would be bound to pay.

Lords WATSON and FITZGERALD agreed.

The appeal was dismissed with costs.

Gandy v. the Gulcher Electric Light and Power Company.

This was an appeal before Lord Coleridge and Mr. Justice Cave, on Friday last, by the plaintiff for a new trial, or that judgment might be entered for the plaintiff for a sum agreed upon, on the ground of misdirection, and that the verdict was against the weight of evidence.

It appeared that the plaintiff in April of 1884 offered to supply the defendant company with some belting for six months for the purpose of driving their dynamos at the Crystal Palace, for the consideration of his being allowed to place a board notifying that the belting belonged to him in the space allotted to the Gülcher Company, by way of advertisement. The offer was accepted, with the condition that the board should meet with the approval of Mr. Wallace, one of the company's directors. Shortly afterwards the board, which was 20ft. long and 4ft. high, was put up at the Palace by the plaintiff without its having been seen by Mr. Wallace. It had, however, only been up a few hours when the manager of the Crystal Palace came and ordered it to be taken away, on the ground of its not belonging to the Gülcher Company, but to an outsider, who, if wishing to advertise, must pay for advertising space. The board was accordingly removed, and a meeting between the parties took place. Mr. Gandy proposed that the bargain should be dropped, but the company objected and offered to pay £60 for the use of the belting for six months from the 1st of May, which offer the plaintiff refused to accept, demanding another £15 for the cost of the board, and no arrangement was come to. The plaintiff afterwards sent to fetch his belting away, but the defendants refused to give it up, and went on using it till the end of the six months, when, as they refused to pay anything for the use or to purchase it outright, Mr. Gandy commenced proceedings against them. The trial came on for hearing before Mr. Justice Wills and a jury, with the result that a verdict was returned for the defendants upon the ground that there was no agreement, the plaintiff not having complied with the condition of getting Mr. Wallace's approval to the board.

Mr. French appeared for the appellant, and Mr. Kingscote for the respondents.

Lord COLERIDGE was of opinion that a verdict should be entered for the plaintiff. It appeared to him that there was a contract entered into

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between the parties, the performance of which was prevented by an obstacle the arising of which was contemplated by neither party when it was entered into. That being so, he thought that as the defendants had had the use of the plaintiff's belting they must pay for it on the "quantum meruit." It had been agreed that the "quantum meruit" should be £50; therefore their judgment was that the verdict should be entered for the plaintiff for that amount.

Mr. Justice CAVE concurred.

Mr. KINGSCOTE asked what order their lordships would make as to costs. The defendants had made an offer of £60 on the 26th of May.

Lord COLERIDGE said they were both of opinion it was a case for no costs.

COMPANIES' MEETINGS & REPORTS.

The West India and Panama Telegraph Company (Limited).

The sixteenth ordinary general meeting of the members of this Company was held at the City Terminus Hotel, Cannon-street, on the 20th inst, under the presidency of Mr. C. W. Earle.

The SECRETARY (Mr. R. T. Brown) having read the notice convening the meeting, and the minutes of the last meeting, which were confirmed, the report of the Directors was taken as read.

The CHAIRMAN: The accounts which we present to you to-day show a decrease in the gross revenue for the half year of £4,235 in comparison with that of the last corresponding period; but that is in comparison with an abnormal half year, in which we had over £5,000 increase. It was a half year of windfalls. We chartered one of our repairing ships to an American company, which brought us in some profit. Then there are some other details which account for the decrease of the present year. For instance, there is the interest upon the reserve fund, which is now carried to the reserve fund instead of to the credit of revenue, and there were some arrears of subsidy which in the corresponding half year became payable, and which do not appear in the present half year's accounts. There is nothing in the working of the concern at all which has caused the falling off in the gross revenue. It is entirely a matter of accounts, I may say, in comparison with an unusual period. The same state of affairs influences the expenditure side of the account. We have an increased expenditure of £5,400, but that is comparing it with a period in which there was £6,075 decrease over the then corresponding period. In that half year—the half year ending 1883—the ships were first of all taken off our hands, as far as expenditure goes, by the International Ocean Telegraph Company chartering one of them, and we brought one of our vessels home for repairs and over-hauling. That ship took out a cargo of cable, the freight of which was credited to the ship, and so the expenses of that half year were materially reduced. There is nothing in the expenditure of the present half year which is abnormal, and our business was conducted at very much the same cost as before. As to the subsidies, the report states pretty fully what the position is. When I last had the pleasure of addressing you we were in negotiation with the three colonies of Barbadoes, Guadaloupe, and Martinique for a renewal of their subsidies. I am happy to say that they have all renewed for various terms—Guadaloupe for ten years, Martinique for five years, and Barbadoes for only three years. The renewal of the St. Thomas subsidy has not yet been settled, though it expired the 31st December last. I met the governor of the colony, which you all know is a Danish colony, while he was in London, and he explained to me, or rather impressed on me, what I had known before, that the colony was in a very poor condition as to finances. It appears that its supremacy as the great shipping port of the West Indies has vanished, and the cause of their losing that supremacy is the existence of the telegraph. The telegraph has benefited very much the other colonies at the expense of the shipping of the colony of St. Thomas, and the governor told me that it was not possible for them to continue the same amount of subsidy which they had been hitherto paying—£1,000 a year. He made certain proposals for our doing a little more work for a little less pay, as usual, and I am in hopes that we shall have a renewal of that subsidy, though I am sure it will not be on the same terms as before, but perhaps at a diminution of £200 a year. I am sorry that the colony of Barbadoes still stops the way with regard to an increase of the subsidies. But it appears from what I have heard, not only from the governor of St. Thomas but from others, that what the island of St. Thomas has lost through the telegraph Barbadoes and some other colonies have gained; and yet while we are mulct to a certain extent of the subsidies payable by St. Thomas for instance, because some of its trade has gone elsewhere, we get no increase from Barbadoes, which has been the gainer. In all these questions, however, we must be ruled by the possible, and we all know the severe depression through which the West Indies have gone. [He then quoted an extract from the *European Mail*, and continued.] When we complain of the treatment of the colonies it is well to bear in mind what a very depressed condition they are in. Supposing it is true (and it is so stated in that excellent paper) that the Government officers themselves are only paid their salaries by driblets, one can hardly expect just now that they should increase our subsidies. The sugar market—sugar is the great staple of course of the West Indies, and its ups and downs very much affect us—is improving. I find that Muscovada sugar was quoted at 19s. 6d. per cwt. in 1882, while at the end of last year it was down to 10s. 3d. At the present time it is 14s. 6d.—perhaps a little better, as yesterday there was a rise—so it is going on towards half-way recovering the great fall it had, and I hope that our affairs will improve in the same ratio. In fact our traffic returns for the current half year are about 6 per cent. increased on those of the corresponding period of the previous year. Perhaps the most important part of the report that we are discussing to-day is the repair of the cable between Jamaica and Porto Rico. That was laid in 1871, before this Board took office. It was never, I believe, a very effective cable in those days. In 1873 a cable was purchased and intended to be laid between Jamaica and Colon, but, very fortunately for us all, it was diverted by the late Board so as to run between Jamaica and Porto Rico, instead of between Jamaica and Colon. The Jamaica and Colon cable, which was then thought hopeless, has since operated very regularly. It was only at the end of 1884 that we were able to restore the original cable between Jamaica and Porto Rico. We have been several years at work on that cable. I think we began in 1881 to seriously examine and effect repairs on it. It was only when the ships were not engaged in more pressing work that we could proceed with the restoration of this very important section, and after a very persistent, troublesome, and expensive course of operations the cable was restored in October last year, and it has worked very satisfactorily ever since. I think that great credit is due to the officers and crew of the ship that was at work. One is apt to talk very glibly of repairs seated here comfortably in London, but if one could carry one's imagination to the long days under a tropical sun, and picture men trying to find a cable, perhaps 1,200 or 1,500 fathoms deep in water, enduring the disappointments and vexations that must occur to those engaged through a very long time in such work, I think you will agree with me that those men deserve our thanks. We are now bringing our second ship, our smaller vessel, home to be refitted. She has been out some years in the West Indies. She was not new when we bought her, and her boilers are giving some symptoms of wearing out. We want some more cable in the West Indies for repairing purposes, and we thought this year a very good opportunity for bringing her home to be overhauled and to take out this cable. I should be very happy to answer any questions you may ask, but meantime I will move, "That the report and accounts to the 31st December, 1884, submitted to this meeting be, and the same are hereby received and adopted; and that, as recommended by the Board, a payment of 6s. per share on account of arrears on the first preference shares be, and the same is hereby declared."

Mr. WM. FORD seconded the motion.

Mr. NEWTON thought that the operation which had been accomplished of repairing the original cable between Jamaica and Porto Rico was exceedingly important to shareholders in telegraph companies, as inspiring them with confidence in the substantial character of their property, and therefore he thought that the fact of such a repair having been effected should be emphasised. He also considered that it might be regarded as a splendid advertisement for Messrs. Silver. He desired to know the present condition of the cable, and the type of the new cable put in.

The CHAIRMAN, in reply, said they quite appreciated the value of the repairs which had been effected, as it had given the Company a duplicate line over the most important part of their system. The quantity of new cable put into the old cable was 232 miles out of a length of 700 miles. He did not mean to state that the cable was in a very high electrical condition, but he supposed that it was in as high electrical condition as most of their cables out there. It was in very good working order, and it had given them no trouble since it was repaired last October. The type of cable with which it was repaired was identically the same as the original cable. It was a sheathed cable. The benefit of the repair had already been felt during two interruptions of the duplicate cable, as the line that was restored last October carried all the work. He had not meant to say that the construction of the cable which had been repaired was not good, for he believed it was as good as any, but it was not skilfully laid. There was no doubt that if the late Board had not diverted the cable which had been meant to be laid down between Jamaica and Colon, and laid it between Jamaica and Porto Rico, the Company would have been in a very great difficulty, for they would have lost the connection for some time with all the islands in the Antilles to the eastward, and all the subsidies.

A SHAREHOLDER asked if any idea had been formed by the Directors as to the effect on the Company of the opening of the Panama Canal.

The CHAIRMAN thought it was very difficult to speculate on such a matter. It would be a long time before it was opened; but when that occurred he should imagine that it would have a great influence on the trade of the region, and that the Company must share in any benefit that arose in that way.

Mr. BAKER said that a large amount was due for arrears on the preference shares, and thought that the Company would be in a very much better condition if some second preference shares were issued in payment of arrears on the first preference shares. As to the £50,000 of 6 per cent. debentures, their reserve fund was now invested at 4 per cent., and he thought it would be a very good thing to invest a portion of the reserve fund in paying off the debentures, which would save £1,000 a year. He really believed that something should be done now with a view of improving the position of the original shareholders.

The CHAIRMAN said that the 6 per cent. debentures were due at the end of next year, and that they could do nothing with them until they became due. When they matured, the Directors no doubt would be able to make some other arrangements; but as to paying them off, unless the money were taken from the reserve fund, he did not know how that proceeding could be accomplished.

A SHAREHOLDER: Pay them off, as the Direct United States Company did theirs, out of the reserve fund.

Mr. FORD: The Direct Company had an ample reserve fund.

Mr. WM. ANDREWS observed that the shareholders might take it that they had not more than an adequate reserve fund.

The CHAIRMAN, in further reply to Mr. Baker, stated that great difficulty was experienced on the last occasion in capitalising the arrears. He

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was open to any suggestion, but his feeling was that until their revenue was a little better they could not bear an increase on the fixed charges. Indeed, it was rather by the skin of their teeth they paid the fixed charges at present.

Mr. NEWTON thought it might be possible to do as the Direct Company had done, and pay off the debentures out of the reserve fund; but as to capitalising their arrears that was impossible, in the opinion of Mr. Horace Davey, whom he had consulted in connection with another company as to capitalisation of arrears.

Mr. CHAPMAN asked whether the Chairman could hold out some hope to the shareholders by mentioning a limit for the reserve fund.

The CHAIRMAN said he did not like to commit himself as to the extent to which they were going to continue the reserve fund. They had a certain basis, formed on the presumed life of a cable, and the rate of interest they could get on securities of a good class; but he thought he could say in a very short time the contributions would be less annually than they were now—he might say considerably less. But a reserve fund which was really a depreciation fund could never be quite closed.

The resolution was then put and carried unanimously.

On the motion of Sir JAMES ANDERSON, seconded by Mr. HENRY HOLMS, Mr. Earle was re-elected a Director, and Mr. Ford was also re-elected to his seat at the Board on the motion of the CHAIRMAN, seconded by Mr. ANDREWS.

Mr. FORD said he desired to thank the shareholders for the renewal of confidence which they had shown in re-electing Mr. Earle and himself, a proceeding by which they had, he thought, expressed their confidence in the whole of the Board. The present Board were elected ten years ago, and he occasionally met some shareholders who asked him was there any hope for the Company, and the solace he gave them was derived from facts—that was from a comparison of the position of the Company in 1874 with the position of the Company in 1884, at the close of the financial year with which they were dealing at that meeting. The income of the Company in 1874 was insufficient to pay its working expenses, being £28,394, while for 1884 it was £91,660. What was their position as to the subsidies? In consequence of the inefficient service which the Company at that time gave, the subsidies amounted to £2,125, whereas in 1884 they received on that head £22,915. Not only had they succeeded in obtaining the full amount of the subsidies, but they had obtained something more—a renewal of them for further periods. With regard to the means of the Company for effecting repairs, when the present Board took office they had a paper ship, the "Suffolk," which, he believed, involved the previous Board in a loss of £24,000. They had now instead of a paper ship two efficient repairing steamers—the "Grappler" and the "Duchess of Marlborough"—which the Company had provided out of the revenue at an expense of £30,000 or £35,000. As the shareholders were aware, the strength of a telegraph company consisted in the duplication of its lines. When, however, the present Board came into office, they had not a single duplicate line, whereas they had since added 870 miles of duplication. As to the question of dividend, up to 1874 not a farthing had ever been paid to the shareholders, but they had since paid altogether £157,587. Ten years ago they were in litigation, and the first act which the present Board was called upon to perform was practically to draw a cheque for £8,000 to meet the expenses of counsel's fees upon the suit then pending between the Company and the India Rubber Company. They settled that litigation, and succeeded in striking off the capital account no less than £181,000; but what was still more important was this. In 1874 the Company was practically insolvent, not having a farthing of reserve fund, but in 1884 they had £105,214 in hand with which to keep up their system, so that its continuance was, in his humble opinion, practically secured. That was the account which he ventured to give on behalf of his colleagues, without whose able assistance it would have been impossible to effect such results. When, therefore, he was asked what hope there was for the future, he asked those who put that question to read the answer by the light of information which the facts he had given them afforded.

Mr. J. G. GRIFFITHS having been re-elected to his position of auditor, a vote of thanks to the Chairman and Directors was passed on the motion of Mr. Newton, and the proceedings terminated.

The Consolidated Telephone Construction and Maintenance Company (Limited).

Report of the Directors to be presented at the fourth general meeting of the Company, to be held at the Cannon-street Hotel, on Tuesday, 26th inst., at 12 noon:—

According to the revenue account the amount standing to the credit of profit and loss is £5,208. 18s. 4d., and the Directors recommend that this amount be carried forward to the next year's account. It will be recollected that at the meeting in December, 1884, it was decided to write off to capital account the sum of £7,500 from the balance of revenue account 1883-4, viz., £10,290. 17s. 9d., and the remainder has been written off the valuation of stores on hand on the 31st March, 1884, the amount being considered in excess of their value. In accordance with the resolution passed at the adjourned general meeting in December, 1884, the capital account has been reduced to £243,787. 10s., of which £168,637. 10s. is issued, and the same has been sanctioned by the Court of Chancery. The relations between the United Telephone Company and your Company continue of a satisfactory nature. Your Directors are happy to state that the manufacturing business has decidedly increased, and that with the extension of the radius granted by the Postmaster-General to the United Telephone Company and its subsidiary companies, a new life seems to have been given to telephonic enterprise, and considerable orders have been executed for the United Kingdom. There is on hand at the moment, amongst others, a most substantial order from the United Telephone Company on behalf of the Postmaster-General. Sample telephones have recently been submitted to the War Office (for use abroad), to the Postmaster-General of Melbourne, and to the Spanish Government, and good results may be looked for in these quarters. There is also under the consideration of the Board a large order for Canada. The shareholders will read with satisfaction that the "Consolidated" telephone is highly approved by the Canadian Government, which has recently favoured this Company with an order; and also by the authorities working the Sydney Exchange, and in many other places. In addition to the orders received from your subsidiary companies in Austria, Portugal, and the River Plate, several orders have been received from the Continent, and it is hoped that in course of time these may be greatly extended. The business of the several subsidiary companies in which this Company is largely interested continues to make very satisfactory progress. The Telephone Company of Austria at the end of March, 1884, had 575 subscribers, paying a gross annual rental of £3,920. At the end of March, 1885, there were 918 subscribers, representing a gross annual rental of £6,433. This shows an increase of 343 subscribers, and of £2,513 on the annual rental. There also were 264 persons wishing to join the exchanges, with a gross annual rental of about £2,000. With regard to the Edison-Gower Bell Telephone Company, at the end of March, 1884, the two exchanges of Lisbon and Oporto had 586 subscribers, paying a gross annual rental of £3,821; and at the end of March, 1885, there were 870 subscribers, paying a gross annual rental of £5,380. This shows an increase of 284 subscribers, and of £1,559 rental during the year. As to the River Plate Telephone Company, on the 29th February, 1884, the number of subscribers in the exchanges of Buenos Ayres and Monte Video was 1,571 with a gross annual rental of £27,000, and on the 28th February, 1885, there were 1,858 subscribers, paying a gross annual rental of £29,400. This shows an increase of 287 subscribers and £2,400 gross income. The total increase in the exchanges, as compared with 1884 and 1885, may thus be stated:—

Telephone Company of Austria	343 Subscribers.	£2,513 Rental.
Edison Gower-Bell Telephone Company	284 ,,	1,559 ,,
River Plate Telephone Company	287 ,,	2,400 ,,
Totals	914	6,472

In accordance with the Articles of Association the following Directors retire by rotation, and being eligible, offer themselves for re-election, viz.:—Major Fitz-Gerald, John Taylor, Esq., and Richard Van-Zeller, Esq. The auditors, J. G. Griffiths, Esq., F.C.A. (Messrs. Deloitte, Dever, Griffiths and Co.), and A. E. Green, Esq., also retire, and offer themselves for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. May 20.		Business Done Week Ending May 20. Highest.		Lowest.
Anglo-American	27,	28	27½		27
Do. Preferred	47½,	48½	48		47½
Do. Deferred	6¼,	6¾	6¾		—
Brazilian Submarine	10⅞,	11	10¾		10 13-16
Cuba	10½,	11	10 11-16		—
Do. Preference	17½,	18½	17½		—
Direct Spanish	1½,	2	—		—
Do. Preference	10½,	11½	—		—
Direct United States Cable	8½,	9	9		8 13-16
Eastern Telegraph	11½,	11½	11½		11½
Do. 6 per Cent. Preference	13½,	14	13¾		13¾
Do. 5 per Cent. Debentures, 1899	105,	108	—		—
Eastern Extension	12½,	12½	12½		12
German Union	9½,	9¾	—		—
Globe Telegraph and Trust	6¾,	7½	7½		6¾
Do. Preference	12⅝,	12¾	12¾		12⅝
Great Northern	13½,	14	13⅝		13½
Indo-European	30½,	31½	—		—
Reuter's	7½,	7¾	7¾		—
Submarine	175,	185	—		—
West India and Panama	¾,	1	13-16		¾
Do. 1st Preference	7¾,	8¼	7¾		7¾
Western Brazilian	5⅜,	5⅝	5½		5⅜
Western Union 7 per Cent. 1st Mortgage	117,	122	—		—
Do. 6 per Cent. Sterling Bonds	100,	103	—		—

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	½	½		—
Oriental	⅛,	¼	—		—
United Telephone	11¾,	12¼	12¼		11 7-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1½,	1¾	1 9-16		—
Do. (fully paid)	2,	3½	3½		—
Hammond Light (£3 15s. paid)	¼,	½	⅜		5-16
Swan	¼,	½	—		—
Maxim-Weston	⅛,	¼	3-16		—

MISCELLANEOUS.

Telegraph Construction	34½,	35½	35½		34½
India Rubber, Gutta Percha, and Telegraph Works	21½,	22½	22		21½

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NOTES.

NOTICE OF REPAIR.—The cable between Para and Maranham is repaired.

NOTICE OF INTERRUPTION.—The land lines in Guatemala are interrupted.

PROPOSED NEW CABLE.—A telegram from Japan announces that it has been arranged to lay an English telegraph cable to Nagasaki.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 22nd inst. amounted to £3,370.

THE AUSTRALIAN TELEGRAPHS.—A post and telegraph station has been erected in the township of Narridy, in South Australia, at a cost of £1,000.

A NEW LAND LINE.—A special land line of telegraph, built by the Commercial Cable Company, and extending from Havre to Paris, was, says an American contemporary, opened on 24th April.

ENTERPRISE.—The New Montezuma Hotel at Los Vegas, N. M., has been fitted by the United States Company with the Weston incandescent lights. There is not one foot of gas pipe on the premises.

THE BRITISH ASSOCIATION MEETING.—The subject of Prof. W. G. Adams's address at the forthcoming meeting of the British Association will be "The Electric Light and Atmospheric Absorption."

TELEGRAPH STORES.—Particulars will be found, in our advertisement columns, of stores, consisting of telegraph apparatus, wire, &c., for which tenders are invited by the Directors of the North Eastern Railway.

THE ELECTRIC LIGHT AND RAILROAD CROSSINGS.—The Springfield, Ill., City Council has passed an ordinance providing that railroad companies shall erect electric lights at all principal streets crossed by said roads.

PERSONAL.—Mr. C. Todd, C.M.G., the South Australian Postmaster-General and Superintendent of Telegraphs, has announced his intention of leaving Adelaide on leave of absence. He will visit England and Europe, and probably America.

SILICIUM BRONZE WIRES.—The silicium bronze wires of M. Lazare Weiller seem to be giving some degree of satisfaction in Switzerland and in Bavaria, where, in addition to Austria, they are largely employed for telephonic and other purposes.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 22nd May were £2,706, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE JABLOCHKOFF AUTO-ACCUMULATOR. — Despite the glowing accounts which continue to be given of this accumulator, we hold our opinion in reserve. A practical trial of the apparatus may not improbably demonstrate its utter worthlessness.

THE ELECTRIC LIGHT AT EASTBOURNE.—The Eastbourne Electric Light Company have recently fitted up new and more powerful machinery in their works in Junction road, and have also made several important improvements in the working of the electric light.

SYNDICAT PROFESSIONNEL DES INDUSTRIES ELECTRIQUES. At a meeting of this syndicate, held last week, it was decided that the general meeting be postponed until the commencement of June. The syndicate has under consideration certain questions relative to the Antwerp and other exhibitions, &c.

THE LONGITUDE OF TENERIFFE.—It is stated that M. Bouquet, membre de l'Institut, has arrived at Santa Cruz de Teneriffe, to determine, on behalf of the Government, the geographical position of that town with Senegal and Cadiz, the cable communication between those points being utilised for the purpose.

THE SCELLOS BELTING.—The Scellos belting, for electric lighting purposes, continues to receive the support of our contemporaries in France. It is said to be of a superior quality of leather, and composed of different bands not exceeding 1·5 metre in length, which are joined together in such a manner as to give great strength and pliability.

THE ELECTRIC LIGHT IN AMERICA.—Lake City, Minn., will soon have the electric light in operation. The Bridgeport Electric Light Company has offered to renew its various contracts with the city for street lighting. The price of lights is to vary from $1.50 per light per year to $1.75, and to burn from sundown to 3 a.m. every night in the year.

ELECTRIC LIGHT TEST.—On the 6th instant, the 600-hour test of the electric lights at the Exhibition Building, West Philadelphia, was completed. The 1,000-hour test is yet to come off. Only six dynamos are now in the building for testing—three of the Edison, and three of the Weston pattern—but more are expected. The tests will not be finished before the middle of June.

SIXPENNY TELEGRAMS.—By arrangement and for the general convenience of members the second reading of the Sixpenny Telegrams Bill was agreed to without a division. Lord John Manners' amendment in favour of free addresses will be brought forward and pressed on the next stage of the Bill. There is reason to believe that it will receive the support of the majority of the House.—*Standard.*

THERMO-ELECTRIC PHENOMENA.—At a meeting of the Reale Accademia dei Lincei, Rome, Dr. Battelli, after giving a *résumé* of the theoretical explanations offered by Thomson and Tait to account for the results obtained experimentally in thermo-electric phenomena, stated also the hypothesis of Kohlrausch on the electrical transport of heat, and showed how, from the conclusions of Kohlrausch, all the formulæ confirmed by experiment might be deduced.

NATIVE MERCURY.—Native mercury has been discovered on the west bank of the Mississippi, about ten miles above New Orleans. An analysis of two triturated specimens of half-dried earth gave the following results :—

1. Weight of soil,	500 grms.	Wt. Hg,	1·4652 grms.	p.c.	0·0029+
2. ,, ,,	500 ,,	,,	1·4687 ,,		0·0029+
Total,	1 kilo.	Total,	2·9339	,, mean, p.c.	0·002934

Or a mean percentage of mercury of 0·002934 per cent.

TRAIN LIGHTING.—The Great Northern Railway Company are lighting one of their trains with "E.P.S." accumulators placed in each coach. The cells are charged by a dynamo driven from the axles, and an "E.P.S." magnetic switch closes the circuit when the E.M.F. of dynamo rises above that of the cells. The Electrical Power Storage Company have lately supplied accumulators for use on the Lancashire and Yorkshire, as well as the Great Eastern Railways.

PHOTOGRAPHY BY ELECTRIC LIGHT.—At the artists' fancy dress ball, recently held at the Prince's Hall, Piccadilly, a large number of photographs were taken throughout the evening by Mr. Barraud, of Regent-street, by the electric light. The

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negatives are said to be as good as those taken by daylight. Two arc lamps, with 10 ampere current, were supplied with current from "E.P.S." accumulators. The installation was carried out by the Electrical Power Storage Company.

THE GROSVENOR GALLERY INSTALLATION.—We are informed that the whole of the power for driving the electric light machinery at the Grosvenor Gallery is to be transmitted through the patent friction pulleys and clutches of Messrs. J. Bagshaw and Sons, of Batley, Yorkshire; and in accordance with instructions from Messrs. Marshall, Sons, and Co., Gainsborough, the firm are also manufacturing one large clutch of 300 horse-power, and others of 150 horse-power each.

THE NATIONAL SELF-BINDING INSULATOR.—This insulator possesses certain new features which appear to be of greater practical value than any improvement made in glass insulators since the introduction of the internal screw-thread. The improvement enables the ordinary tie-wire to be wholly dispensed with, the insulator, with its clip, being so formed that the line-wire is readily placed in position, and rigidly secured without the aid of tools. The insulator can be applied in any position, wherever the ordinary pattern is available.

DEATH OF A POST OFFICE OFFICIAL.—The death is announced of Mr. Thomas Boucher, who was appointed to the Post Office in 1834, and subsequently promoted to be Controller of the Circulation Department. In 1875 he was raised to the rank of Surveyor General, which position he held until 1877, when, on account of failing health, he retired from the service. When in 1855 Mr. Rowland Hill commenced the London Postal District System he was ably assisted by Mr. Boucher, to whom the greater part of the arrangements were entrusted.

ELECTRIC SIGNAL BALLOON.—A new departure in military signalling has been made by Mr. Eric S. Bruce, son of the late General Michael Bruce, who commanded the Grenadier Guards. He places an incandescent lamp in the body of a translucent captive balloon, and flashes signals according to the Morse code by making and breaking contact, thus permitting signalling to be carried on at great altitudes and to considerable distances. Mr. Bruce is experimenting with various lamps and batteries, so as to determine those best suited to his purpose, and he will describe the invention at his forthcoming lecture at the Birkbeck Institute on 10th June. Moreover, the balloon is soon to be on view at the Inventions Exhibition, in the War Department, Group 25, near the main entrance.

ELECTRIC LIGHTING IN LUXEMBURG.—The first application of the electric light in the Grand Duchy of Luxemburg was the temporary installation of a Schuckert dynamo and fifteen arc lamps, for the purpose of facilitating the progress of the new Thomas Gilchrist steel works at Dudelange or Dudelingen. It is expected that two blast furnaces will be blown in during June, and the steel works started in October, when there are to be three dynamos, two at work and one in reserve. A novelty in the permanent installation is that the same engine, horizontal, with air-pump and condenser in line with the cylinder, will drive the Kley fans for blowing the pig and spiegel cupolas when required during the day, and the Schuckert dynamos at night. MM. Glaesener Frères have lately completed an installation of incandescent lamps, maintained by their new secondary batteries, in the Luxemburg Prison.

OVERHEAD WIRES AND THE COURT OF COMMON COUNCIL.—At a meeting of the Court of Common Council held recently the Chairman of the City Commission of Sewers was asked if it were true that the Streets Committee and the officers of that Commission were to spend the Whitsun holidays in Paris in order to investigate the system of underground telegraphic and telephonic communications, and if so whether the visit would cost about £800, and whether that sum would come from the City's cash or otherwise. The Chairman of the Commission, who eventually rose in response to loud calls, said the Commission had been considering, in the interests of the public, the dangers and inconveniences arising from the present system of overhead telegraphic and telephonic wires, and they were called upon to give evidence on the subject before a Select Committee of the House of Commons. They had commissioned a certain small deputation of their number to visit Paris to examine the successful system of underground telegraphic and telephonic communication. Their visit, which would be paid, like their other expenses, from the rates, would cost less than their obtaining the information through experts, and as the results would be to the public advantage, the money would be well spent. As for going in the Whitsun holidays, that was the only time at which the deputation, who were all business men, could go.

WHIT MONDAY AT THE INVENTORIES.—In an article entitled "A Monster Day at the Inventions," the *Daily News* says:—"In due time the conservatory and main buildings were suddenly outlined with what seemed to be small copper nails, and when the nails grew as by magic into bright lamp lights a roar of surprise and admiration drowned the music of the bands. This marvellous electrical illumination is not literally effected instantaneously. The installation throughout the grounds consists of twenty-three circuits, made into eight sections, and to each section there is a switch controlled by Sir Francis Bolton or his assistant in the clock tower. First, therefore, to appear were the glow lamps at the upper end; then in quick succession followed those of the main buildings, trees, and flower beds. The general effect was enthusiastically recognised. The illuminations are, as we learn, however, still in the experimental stage. These 20,000 glow lamps almost simultaneously starting into light are a marvel of electrical progress; but as they never twinkle, and are necessarily arranged with regularity of line and pattern, they have somewhat, as a general design, the prim formality of an Italian garden. Coloured lanterns suspended from the branches would supply the small effect that is wanting for perfection. Last night, however, the lamps and the lovely fountains as they were proved all-sufficient in affording pleasure. It was, under all the circumstances, a grand day at the Inventions."

RADIATION V. ELECTROLYSIS.—Mr. Frank Lockwood recently had occasion to examine a lamp which has been in use a long time in the premises of a large silver-ware manufacturing firm in this city. It is an ordinary 16-candle Edison lamp, and at present has almost the appearance of a solid globe of bronze, so great is the deposit of copper within it. The explanation is apparent; electrolysis of the copper has resulted in the fourth condition of matter, and not as ordinarily in cases of this kind, in the third or gaseous state. The peculiar effect is due in part to radiation and not simply to decomposition. This is demonstrated by the directions taken by the matter, and by the fact that the distribution has taken place from one point, which, so far as can be judged, is one of the copper clamps holding the filament of carbon. It is also verified by the fact that from the top of the lamp to where the other clamp is situated a thin line of clear glass may be observed, following the line of the carbon filament and evidently protected by it from the deposit of particles proceeding from the centre of

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radiation. It is a somewhat novel phenomenon, and we think on that account deserves notice. Aside from the elaborate experiments of certain physicists, the often peculiar and sometimes startling effects of the fourth condition of matter have perhaps not received the attention they are justly entitled to. The study of these phenomena is at once entertaining and instructive, and undoubtedly will in time become more general than it is at present.—*American Electrician.*

THE TELEGRAPHS IN THE FAR EAST.—No action has yet been taken by the Government in the direction of constructing an independent cable to Singapore, and delay is much deprecated in Hong Kong. The Hong Kong correspondent of *The Times* says:—"Three things are well known to be needed immediately in the Far East, and these are not mere *pis-allers*, but permanently required when the fortifications, &c., are completed—namely, (*a*) a sufficient number of torpedo boats, properly manned and equipped, for all the principal harbours and coaling stations; (*b*) telegraphic communication, by a direct English cable, from Hong Kong to Singapore; and (*c*) a reinforcement of the garrisons, especially at places like Singapore and Hong Kong. The importance of direct telegraphic communication so as not to pass through hostile or possibly hostile territory, so invaluable at the outbreak of any war, need not be urged here. To a nation like ourselves, with the enormous interests involved, one would imagine that we should recognise the absolute necessity of being forearmed by being forewarned, and this at any cost. Far from costing an enormous sum, however, this might have been accomplished by a small guarantee contributed by the Imperial Government, Hong Kong, and Singapore, and, if commenced when the scare begun, have been now working. Nothing whatever has been done in this matter; it has not even entered upon the chrysalis stage. The official answer to our demands is easy enough to predict. Put, of course, in a very much more plausible form, the responsible officials will tell us:—'If the colonies and Indian ports want torpedo boats or English cables they must pay for them themselves.' A terrible blunder will be committed if this attitude be persisted in."

RESEARCHES ON THE ACTION OF THE COPPER-ZINC COUPLE ON ORGANIC BODIES.—Dr. J. H. Gladstone, F.R.S., and Mr. Alfred Tribe have extended their previous researches on the action of the copper-zinc couple on organic bodies to compounds of the aromatic series. Ortho and para bromotoluene are not attacked by the couple, but the isomeric benzyl bromide, C_7H_7Br, is very readily acted upon. So rapid, indeed, is the action that it is necessary to operate with only very small quantities at a time. Some bromide of zinc is formed, but the main products are bromhydric acid and two apparently different resin-like bodies, the one soluble and the other insoluble in ether, which become viscid at a little above the ordinary temperature, and are decomposed on distillation. Though no specimen was obtained pure, combustions indicated that they were hydro-carbons of the empirical composition C_7H_6, and this was supported by evidence derived from their specific refraction and dispersion. It is proposed to name them α and β benzylene. The bromo and nitro-compounds are uncrystallisable bodies. *In the presence of ether* the reaction is very different. The zinc is dissolved in a larger proportion than would be necessary to form $ZnBr_2$; in fact, the proportion of zinc to bromine is very constantly 1:1·6. The organic zinc compound was not isolated, but it is decomposed by water with the formation of zinc hydroxide, zinc bromide and toluene. When the compound is strongly heated, dibenzyl also separates from it. *In the presence of absolute alchohol* the reaction takes another form. Toluene, C_7H_8 is produced, and a bromo-zinc organic compound, doubtless bromoethylate of zinc, $ZnBr.OC_2H_5$. Some dibenzyl was also formed. *In the presence of water* the action was slow at the ordinary temperature. The benzyl bromide was found to be mainly resolved into dibenzyl and zinc bromide, but some toluene and zinc oxybromide were also produced. One or two other compounds formed in smaller quantities were partially examined, but the investigation was not carried further on account of the extremely noxious character of the vapour of the original substance.

MEASUREMENT OF STRONG ELECTRIC CURRENTS.—In a letter to Silliman's *American Journal*, Mr. J. Trowbridge says:—"I have no reason to change my belief, that a dynamometer is the most suitable instrument for measuring strong currents. I have lately, however, employed the cosine galvanometer for this purpose in the following manner:—The galvanometer is mounted so that its compass is at the centre of a large circle of wire, the plane of which is vertical and is in the magnetic meridian or in the plane of the needle of the compass, whatever that is. When the current from a dynamo machine is passed through the large vertical coil, which may consist of a single wire, the arrangement answers as a tangent galvanometer. I then connect the movable coil of the cosine galvanometer with a Daniell cell of known electromotive force, place in the same circuit a resistance so large that the battery resistance can be neglected, and having joined the poles in such a manner that the deflection produced by the coil of the cosine galvanometer shall be opposite to that produced by the current from the dynamo machine in the large outer coil, I incline the coil of the cosine galvanometer until the compass-needle is brought again to zero. We then have, if we represent by F and F′ the force produced at the centre of the coils by the current from the dynamo machine and by the Daniell cell, S and S′ the respective currents, r and r' the radii, n and n' the number of coils in the two galvanometers, and H the horizontal force of magnetism:—

$$F = \frac{2\pi n S H}{r} = P' = \frac{2\pi n' S' H}{r} \cos\alpha, \quad \text{or } S = \frac{S' n' r}{n r'} \cos\alpha.$$

The strength of the current from the dynamo is thus simply obtained in terms of the current from the standard Daniell cell, and the method is independent of the strength of the earth's magnetism, or of the special field in which the instruments may be placed. The diameter of the outer coil can be diminished by employing Prof. Brackett's method of passing the current through one coil in one direction, and through an inside coil in another. In an experimental trial I employed simply a scaffolding of wood, upon which a single turn of wire was fixed as a vertical circle.

TELEGRAPH CONSTRUCTION IN CHINA.—Our Hong Kong contemporary, the *China Mail*, says:—"In November last we referred to the telegraphic communication to be established between the port of Pakhoi and a point in Kwangsi (Wang Chow) on the main line from Canton to Lung Chow (on the Tonquin frontier), which passes Nanning. This line was completed on the 4th of February; the first message went through at 4 p.m. on that date, and it was notified that the Chinese Telegraph Company's lines had been placed at the disposal of the public generally free of charge *for all messages handed in at Pakhoi* for the term of three days ending on the evening of the 6th of the month mentioned. We understand that the telegram received by us was the first private message forwarded. The building of this line, which passes by Lingshan and Liemchow, has been a hard task, and those engaged in it have had to endure much suffering from the inclement weather and severe cold experienced throughout. The work was calculated

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to take three months, but it has been completed some ten days ahead of that time. Taking into consideration the facts that one month was lost in waiting at Wang Chow for poles and wire (which should have been there in October), that the country traversed was mountainous and imperfectly surveyed, great credit is due to the energetic Danish gentleman, Mr. Mühlensteth, of the Great Northern Telegraph Company, by whose skill and experience the work has been accomplished. In recognition of the great exertions he has made to complete the Wang-Chow-Pakhoi line under extremely adverse circumstances, his valuable services have at once been secured by the Chinese Government for the building of a new line from Liemchow westward towards the Anamite frontier, passing by Chin-chow and Yam-chow. He set out on this new work on the 7th inst., and the line is expected to be completed in about six weeks. Two other Danish gentlemen, Messrs. Jensen and Madsen, belonging to the Chinese Telegraph Company, have also just started for Liemchow to proceed with the building of a telegraph line from that place to Hainan (surveyed by Mr. Jensen a couple of months ago), which is to connect this port with Kiung-chow. The cable from Hoihow to Cape Cami was laid in November last. This line will also be completed in about six weeks, material not failing. The only station between this and Wang-chow is at Liemchow, whence lines will thus go out in four directions."

THE ELECTRIC LIGHT IN CHICAGO.—Our American namesake says:—The United States people have lately put an extensive plant in the Post Office portion of the Government buildings in Chicago; and, by the way, despite the defeat of the Republican party in November, these seem to burn just the same under a Democratic administration. The same company are wiring large plants in the Home, the North Western, and the Royal Insurance buildings, the Mahler building, and the barber shops of the Palmer House. In these several plants there is a total of about 4,270 glow lamps. The Edison people, too, are full of work, wiring the new Board of Trade building, adding to the Pullman building plant, and the county buildings at Wauwatosa, near Milwaukee, and will soon be wiring the city buildings and the two tunnels from the south division to the west and north divisions of the city. This latter plant will consist of two engines and four generators, which will be placed in the basement of the city buildings, with a capacity for 1,500 lamps of 16 candle-power. Of these about 300 will be distributed between the tunnels, the remainder in the corridors and various offices of the city building. It is proposed to light only a portion—about one-third—of the tunnel lamps during daylight, the entire number being in use at night, while an average of three hours per diem will be the use of those in the building. Advertisements for bids were published early in the past winter, and the Edison Company made proposals for furnishing the plant in accordance with the above data, for 41,375 dols., and the Council at the regular meeting of the 30th of March, ordered: "That the controller is hereby directed to enter into a contract with the Western Edison Company, in accordance with the proposition of the said company, dated 26th December, 1884, in regard to lighting the buildings of the city, for the sum of 41,375 dols." The city officials, whose duties require artificial light to a greater or less extent, are as tickled as a boy with a new top at the approaching release from the thraldom of gas. As one of these remarked to the writer, "This light is like fresh eggs compared to the kind that are only fit for scrambling, when placed alongside of gas. A gas plant is a bad egg all the year round—a bad colour, pollutes the air, and—smells." Then again M'Vicker's Theatre is to be lighted with incandescent lights. So is the new Chicago Opera House; and the present Grand Opera House has lately blazed up with glow lights. This last is a Mather-dynamo-Perkins-lamp plant, and makes a very pretty show indeed. A stage trick accompanied its inauguration. On the night of its *début* the auditorium was lighted up as usual with gas jets. All being ready these were extinguished, and electric lights substituted. The audience, at first astonished and bewildered, then pleased, saw the joke, and broke into the most uproarious applause, indicative of their approbation.

BOOKS RECEIVED.—"On the Mechanical Characteristics of Lightning Strokes," by Col. the Hon. Arthur Parnell. The main objects of this essay, which is a reprint from the *Quarterly Journal* of the Royal Meteorological Society, are as follow: First, to show that lightning is not a sort of electric fluid that descends from the clouds, injures buildings and persons in its course, and dissipates itself in the earth, but that it is a luminous manifestation of the explosion caused by two equal forces springing towards each other simultaneously from the earth and the under surface of the inducing cloud, and coalescing or dying out nearly midway between the two plates of the electrical condenser formed by the earth and cloud; secondly, to demonstrate that of these two forces it is the earth-sprung or upward force alone which injures buildings, persons, or other objects on the earth's surface, and which constitutes tangibly what is known as a lightning stroke. Some of our readers, we are afraid, will find this hypothesis rather difficult of explanation, unless they accept the author's statement that in 1759 the English philosopher Symmer revived and remodelled Dufay's ideas into the "two fluid" theory that has since been *universally accepted as the correct one.* The italics are our own.—"Facts Proving that Lightning is a Composite Force," by Mr. Wm. Boggett, is a publication upon somewhat similar lines. Mr. Boggett's ideas on the subject of electricity, like those of other people whose knowledge of science is superficial, are peculiar. He says: "In the hope of removing all doubts from the minds of electricians as to my conception that lightning is a composite force, I append the following facts." We repeat *facts*:—"(1) Electric force in an active state always comprises two currents. (2) The said two currents invariably move in opposite directions, owing to one being positive and the other negative. (3) Each of the two currents has electricity as its basis, &c." It is kind of Mr. Boggett to remove our doubts in this fashion. We are entirely with him in his belief that "lightning results from electric action," and that "thunderstorms frequently happen on the ocean," and if we ask with him whether "the most gifted electrician can explain from what other source than water electricity is derived," it is only in the hope that a few facts on the subject will eventually reach a quarter where they are obviously required.—"A German Grammar and Reader for the Use of Science Students," by Emil Beyer, lecturer on German at the Technical College, Finsbury, E.C. (David Nutt, 270, Strand), is a useful little work, containing besides the grammar proper a compendious vocabulary of words relating to the mechanical, chemical, and electrical sciences. It will facilitate in a very great measure the study of treatises of a technical nature, and we must, therefore, congratulate the author upon the apparent thoroughness of his labours.

ELECTROLYSIS OF DILUTE SULPHURIC ACID.—An abstract of a paper by M. F. Richarz, in the last issue of the Society of Telegraph Engineers' *Proceedings*, says:—"In his experiments the author at first made use of a U tube, but this had to be abandoned, as the results were not concordant, owing to the concentration of the sulphuric acid in the leg of the tube containing the positive electrode. A straight tube was then

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used, which was clamped in a vertical position. The positive electrode was formed by a platinum wire placed in the upper part of the tube, the two ends of the wire being sealed into the glass at two points vertically below each other. The object of having both ends brought out of the tube was in order to enable the wire to be brought to a red heat by the passage of an electric current, it having been found that, unless this were done previously to each experiment, the results did not agree. The negative electrode finally decided upon, after a trial of thin plates of platinum, was a similar platinum wire fused into the opposite side of the tube, and lower down than the positive one. The whole apparatus was kept at zero temperature by being surrounded with melting ice; and the current used for effecting the electrolysis was kept constant by observing the deflections of a tangent galvanometer, and putting in or cutting out portions of a resistance which formed part of the circuit. The galvanometer constant having been accurately determined, it was also possible to calculate the total amount of gases which should have been liberated by the passage of the current, and thus to check the quantities determined by the chemical analysis. The quantity of ozone formed was determined by the amount of iodine set free from a solution of potassium iodide, this amount of iodine being estimated by its reaction on normal sodium sulphite. The sulphur trioxide formed was calculated from its action on ferrous sulphate, which it converts into ferric sulphate. For the determination of the hydrogen dioxide, the permanganate of potash test was used. At first the positive platinum wire electrode was not heated, and it was then found that the results did not agree. The author sought for the cause of this, in the first instance, in the negative electrode, but he found that this did not affect the result, nor did the evolution of hydrogen, nor impurities such as lead or manganese in the electrolyte, and he therefore concludes that this alteration of the positive electrode was due to the evolution of oxygen. The reduction of the sulphur trioxide at the negative electrode causes a disappearance of a quantity of hydrogen equivalent to its own oxygen, which will be shown by a deficiency in the total quantity of gases produced. It was clearly proved that the sulphur trioxide was reduced by the nascent hydrogen; also that the formation of these higher oxides is dependent on the temperature, and that the quantity of sulphur trioxide decreases much more quickly with rise of temperature than the ozone. The author also found that the quantity of these evolved gases increased with the current density, and that he consequently got better results when using wires than when using plates. The degree of dilution of the sulphuric acid also has its influence on the amount of gas evolved, and it was found that the largest quantity of sulphur trioxide was formed when the electrolyte contained from thirty to forty per cent. of sulphuric acid. It was more difficult to determine the quantity of ozone, but it seemed at any rate that with a solution containing more than sixty per cent. of acid the quantity was less than with more dilute solutions."

THE PHYSICAL SOCIETY OF BERLIN.—At a meeting of this society, held on the 6th March, Dr. Kalischer described a new secondary battery intended to overcome the disadvantage of the usual accumulators, namely, that the sheet of lead used as anode got very soon destroyed. This object he attained by adopting a very concentrated solution of nitrate of lead as electrolyte, and iron as anode. The iron, on being immersed in the solution of lead, became passive and resisted every corroding effect of the fluid; in other respects the peroxide of lead on the electric charge became deposited at the anode as a very firm coherent mass enveloping and protecting the iron on all sides. The charge was continued till the greater part of the nitrate of lead was decomposed, a condition which was marked by the occurrence of a greater development of gas at the anode. At the beginning of the charge all development of gas must be avoided, as otherwise the peroxide of lead, or, more correctly, the hydrate of peroxide of lead, became covered with bubbles. As cathode a sheet of lead was used, but it was attended by two disadvantages. In the first place the lead, during the charge, separated itself at the cathode into long crystal threads, which soon passed through the fluid, and produced short closing (of the current). In the second place the nitric acid, which remained in the fluid after the separation of the lead, acted very powerfully on the sheet of lead. Both disadvantages Dr. Kalischer avoided by amalgamating the cathode. This accumulator of iron, concentrated solution of nitrate of lead, and amalgamised lead yielded, after the electric charge, which could be carried out without any special preparations, a current of about two volts. After about six hours' discharge, however, the electromotive force sank to 1·7 volt, but, on the battery being left to itself for twenty-four hours, it became a little increased. According to the measurements hitherto taken, the functions of this accumulator were satisfactory. An attempt to substitute sulphuric manganese for nitric lead in this battery did not answer the purpose, as the peroxide of manganese separated itself, not in a continuous layer, but in loose scales. At another meeting of the same society, on the 20th March, Dr. Gross, starting from theoretical considerations, instituted the following experiment:—Two iron electrodes, overlaid with sealing wax in such a manner as to leave only the terminal planes free, were dipped into a solution of chloride of iron, closed by means of a galvanometer into a circle, and any inequalities there might happen to be adjusted according to the Poggendorf-Du Bois-Raymond method. When now one electrode was surrounded by a magnetising spiral, there was seen, on its being magnetised, an electric current passing from the magnetic electrode through the fluid to the non-magnetic electrode. It might be thought that the current was a thermo-electric one, produced by the warming of the magnetising spiral; but a delicate thermometer showed that the air within the magnetising spiral was but 2° warmer than the surrounding air. Besides, the electrode that was to be magnetised was surrounded by a double cylinder, through which water of a temperature 12° below that of the air was constantly flowing; and yet, notwithstanding this powerfully cooling influence, the current always passed from the magnetic to the non-magnetic electrode, whereas a thermal current must have passed from the warm to the cold electrode. The electric current was therefore produced, not by a difference in temperature, but by the magnetisation of the one electrode. The current continued so long as the electrode was magnetised. If the electrodes were now brought into a tube, and so arranged as to lie behind each other in the axis of the tube, with their free terminal planes turned to each other, then, on the magnetisation of one electrode, an electric current again set in, passing now, however, from the non-magnetic electrode, through the fluid, to the magnetic electrode. The direction of the current was consequently dependent on the direction of the magnetic axis to the electrolyte and the second electrode. As conducting fluid only sulphates of iron could be used in these experiments, and of these only such as received the free terminal plane of the electrodes nakedly. Dr. Gross believed that the currents demonstrated by him in the experiments thus described were related to the thermo-electric currents between magnetic and non-magnetic iron wires, which were a subject of study to Sir William Thomson.

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THE CHARGING OF SECONDARY BATTERIES.*

BY WILLIAM HENRY PREECE, F.R.S.

1. I have for the past twelve months been experimenting with secondary batteries, with a view of getting an efficient, uniform, and constant source of currents for electric lighting my house, and I have succeeded beyond my expectations. Some new facts have developed themselves during my experience, which I have thought of sufficient importance to bring before the society.

2. The cells are of the Planté type, manufactured by the Elwell Parker Company, of Wolverhampton. Fourteen plates of plain sheet lead, 17in. × 11in. are suspended in well insulated wood boxes filled with diluted sulphuric acid in the proportion of about 1 to 10. These plates are grouped in two groups of seven, each group being soldered to a lead strip, forming alternately the positive and negative poles of the cell. The plates of the respective poles are prevented from touching each other by ebonite grids or separators†. Each plate offers a surface of 1·3 square foot, so that the total surface of lead of each group opposed to each other is 9·1 square feet; that is, 9·1 square feet of peroxidised lead is opposed to 9·1 square feet of spongy lead. I use 24 such cells.

3. My charging current varies from 3 to 3½ amperes per square foot, while the current discharge used in lighting my house varies from 1 to 1½ ampere per square foot. The total weight of each cell is 120lb. The plates are prepared by the Parker-Planté process before insertion in the cell, those forming the positive pole being well peroxidised, while those forming the negative pole are well coated with spongy lead.‡ They are thus, when put together, prepared at once to be charged. If they are not at once charged, local action sets in, and lead sulphate is injuriously formed.

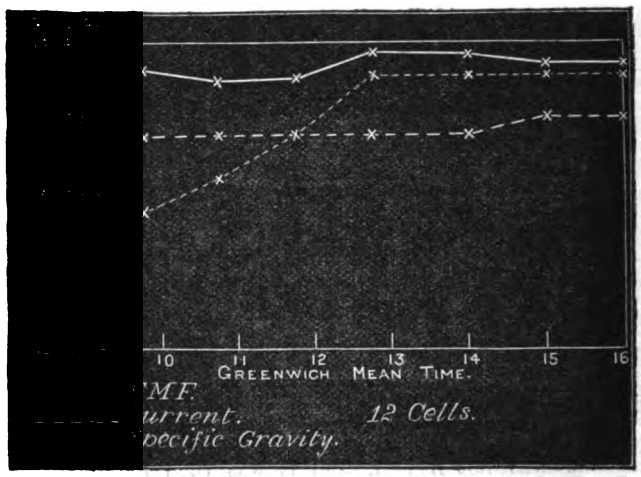
4. I have cut away a small portion of the centre of the central plate of each cell to admit a hydrometer having a scale graduated from 1·050 to 1·150. The changes of the density of the liquid and of the colour of the plates give the fullest and clearest indications of the behaviour of the cell. The condition of the surface of the peroxidised plate as felt by the finger is also good evidence of its condition. If a plate is yellowish-brown and rough, it probably makes bad contact with the lead terminal; if black and hard, it wants the density of current regulated; if plumb-coloured and greasy to the touch, it is in good order, and working well.

5. At the present time I am charging my battery twice a week, putting in at each charge about 120 ampere-hours; the battery is charged in two sections. During each charge observations are made every hour, and sometimes every half-hour (1) of the strength of current flowing through; (2) of the electromotive force; and (3) of the density of one or more of the cells. The relation of these three quantities tells me the condition of the charge. The diagrams (Nos. 1, 2, 3, 4) are typical cases.

Take No. 4, which is the diagram of this morning's (April 28) charge of 15 cells. The following are the particulars:—

	E.	C.	D.
9:0 a.m.	37·7	32·24	1.115
10:0 „	40·2	32·24	1·119
11:0 „	42·5	31·50	1·121
12:0 noon	42·5	30·74	1·123
1:0 p.m.	42·5	29·95	1·124
2:0 „	42·5	29·95	1·124

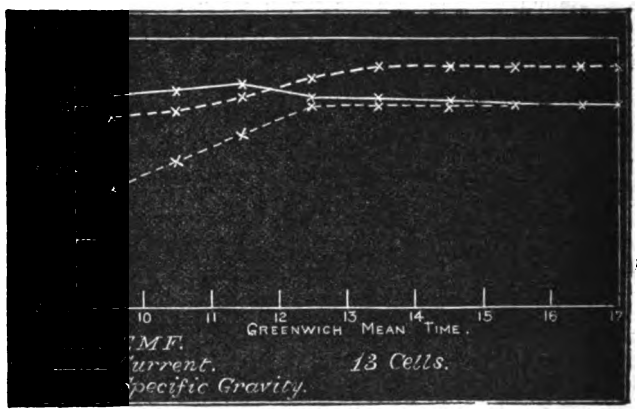
6. It is evident that after four hours' continuous charging the battery was full, for the density, the electromotive force, and the strength of current became constant. The same scale of ordinates is used for volts and amperes. When each magnitude reaches its constant bubbles of gas are freely given forth, and energy is being wasted. The variation of the electromotive force and current strength is clearly due to the counter-electromotive force of the cells, which becomes a maximum only when the plates are fully formed. The counter-electromotive force partakes of the character of a higher resistance opposing the charging current, and increasing the proportion of the current through the shunt of the dynamo. Hence the changes of electromotive force are more marked than those of the current. Indeed, the changes in the electromotive force, as given by the voltmeter, are sufficient alone to



No. 1.

indicate the progress and completion of the charge. They are more reliable than the evolution of gas. (My dynamo is shunt-wound; my voltmeter is Cardew's, a most reliable, simple, and valuable instrument; and my current meter a Siemens electro-dynamometer.)

7. I was at first much troubled with electrical leakage. The current escaped over the edges of the box through creeping, and the formation of moisture from the spray of the solution when bubbles of gas arose in the liquid and burst on the surface. This was quite cured by standing each box on three white porcelain supports of the form shown in the accompanying Fig. A, the cups being half filled with resin oil on Messrs. Johnson and Phillips' plan. It is now quite impossible to measure the leakage except with a delicate galvanometer, and the insulation may be said to be practically perfect.



No. 2.

8. The E.M.F. of the battery at its terminals:—

When charging	2·25 per cell.
When idle	2·05 „
When discharging	1·90 „

* Paper read before the Royal Society.

† These ebonite grids were introduced by Mr. Charles Moseley, and have effectually removed one incessant source of trouble in these cells, viz., short-circuiting through the buckling of the plates.

‡ The Parker-Planté process consists in immersing for a few hours the lead plates in a solution of nitric and sulphuric acids in these proportions:—Nitric acid 1, sulphuric acid 2, water 17, before fixing in the cells. This not only chemically cleans the lead surfaces, but it favours the formation of sulphate of lead in such a way as to be readily converted into lead peroxide and spongy lead on the passage of a strong current through the cells. The formation of the cells is thus greatly expedited.

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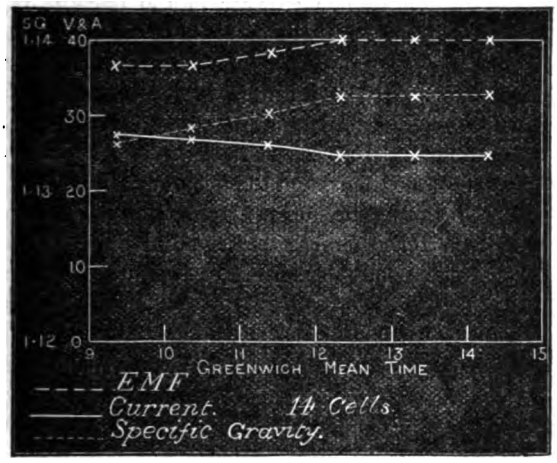
The internal resistance is, per cell :—

When charging..... ·0060ω
When discharging ..... ·0017ω

9. But the latter varies very markedly with the strength of current of discharge. This is shown by the following experiment made with 23 cells of a smaller type than those described above, which are used in the Post Office.

Current of discharge in amperes.	Internal resistance in ohms.
4·39	0·7608
7·25	0·4607
15·84	0·2816
25·07	0·1969

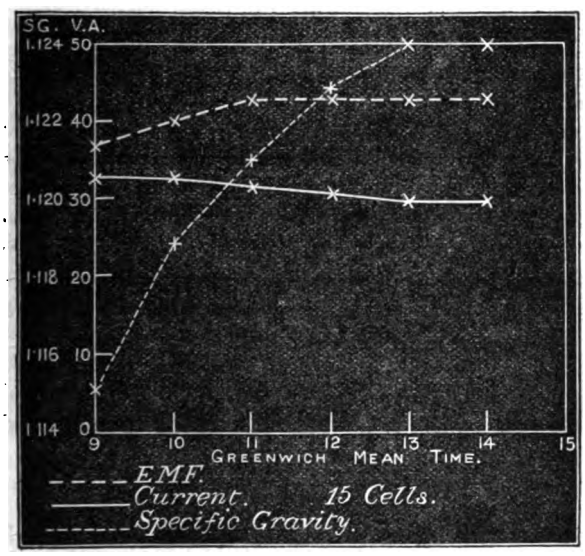


No. 3.

10. Thinking that the remarkable diminution of internal resistance might be due to the evolution of heat, I measured the temperature with a delicate thermometer.

Normal temperature of cell 12½° C. Current of discharge :—

5 amperes ..... No alteration of temperature perceived.
10 „ ..... An exceedingly slight change.
16 „ ..... About 12⅝°.
20 „ ..... Barely 13°.



No. 4.

The current in each case was kept on for twenty minutes, hence the diminution is not due to heat. Since the internal resistance varies in this way, I now always take the internal resistance with the same current, viz., 10 amperes.

11. The capacity of these batteries certainly improves with age, and up to the present time I have seen no sign of decay or deterioration. M. Planté informed me that, though in course of time the peroxidised plate becomes very brittle, it is impossible to peroxidise it completely through; there always remains a metallic core to give it strength. I find that this is so. Up to the present moment I have made no careful measurements of the efficiency of my battery. I cannot do so without deranging the lighting of my house, and I regard observations on single cells as illusory. I put in about 240, and I take out about 200 ampere hours weekly, and I do not observe any change or fall in the electromotive force. When the electromotive force of these cells falls, it falls rapidly, indeed, almost suddenly. Occasionally one plate of a group becomes inactive from undue local action, or from bad connection (shown by the colour). I remove this cell and put it in what I call a "hospital" cell, where it is brought into order either by a greater density of current or by reversal.

12. Reversing has a great beneficial action on a cell ; it not only improves its capacity, but it removes any cause of irregular working. It is advisable to do this periodically. I have two extra cells, which enables me to have two cells always under reversal by means of the charging current. It takes from 1,000 to 1,200 ampere hours to reverse a cell, so that at this time of year it takes a month or more to complete the operation, and it will take a year to reverse the whole battery. I have thus up to the present time reversed 16 cells.

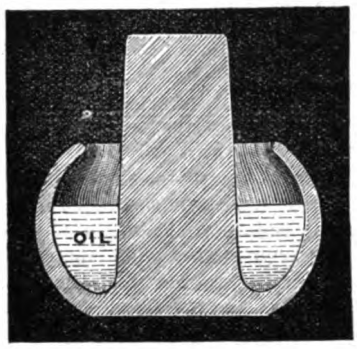


Fig. A.

THE ELECTRIC LIGHT IN LONDON.—From the report of the Metropolitan Board of Works, which has just been issued, we extract the following:—"The lighting by electricity of the streets of London has not apparently made much progress during the last year or two, notwithstanding the numerous provisional orders granted by the Board of Trade under the provisions of the Electric Lighting Act of 1882, and confirmed by Parliament. In some places, indeed, there has been a temporary retrogression, which, however, it may be hoped is only temporary. The Victoria Embankment, for instance, and Waterloo Bridge, which for about five years were lighted by electricity under an arrangement made by the Board, originally with a French company but afterwards with the Jablochkoff Electric Light and Power Company, are now again for a time dependent for their light upon gas. The agreement with the company came to an end on 30th June, 1884, and, as the Board had had several times to complain of the sudden extinction of many of the lights during the hours when they ought to have been constantly shining, and as moreover the affairs of the company were then in liquidation, the Board was unable to renew the agreement. The Board by advertisement in the newspapers invited tenders from parties willing to undertake what had hitherto been entrusted to the Jablochkoff Company, and a small number of tenders were received. None of them, however, offered terms which the Board considered satisfactory. It was therefore decided to revert to gaslight for a time, and to make further inquiries with reference to the most suitable and economical method of lighting by electricity."

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE DEBATE ON SIXPENNY TELEGRAMS.

The second reading of the Telegraph Acts Amendment Bill was allowed to pass last Friday without opposition, on the understanding that if anyone of its opponents could devise a measure securing the same benefits without inflicting a greater loss on the revenue, the Postmaster-General would reconsider the Bill in Committee after the Whitsuntide holidays. If this assurance is to be taken literally for nothing more than it promises, and if Mr. Shaw-Lefevre stands to his pledge to pass the measure on these conditions and no other, then we may safely say that in the month of August next the experiment of a sixpenny telegraph rate on the Continental model will be begun. For it is perfectly evident that no alternative scheme yet suggested, or possible, will meet the conditions imposed. But if the offer which disarmed opposition to the second reading of the Bill betrayed any misgiving as to the soundness of the case on which the Government proposal rests, there will be no lack of critics in Committee who will do their utmost to invite or extort concessions of a kind which from a financial and business point of view would render the experiment disastrous.

Both in Parliament and in the Press there are signs of opposition to the Bill, not perhaps sufficiently strong to upset it, but just sufficient to make its fate uncertain on a critical division if the Government is not thoroughly satisfied that the essential feature of the scheme must be maintained. This essential feature we hold to be, not the maximum number of words for which the charge of sixpence is to be made—though the maximum is sufficiently liberal—but the abolition of the free addresses. It is against this provision, of course, that all the opposition is directed; not because the commercial community objects—quite the contrary, for commercial men see perfectly well that they will be large gainers by the change—but because it is supposed to inflict some hardship on the general public, and the poorer classes in particular. The pretence of objecting to the curtailment of addresses in the interests of the Telegraph Department can be dismissed as of no account; the Department may be presumed to know their own business, and we have their assurance that they apprehend no difficulty in respect to the delivery of telegrams when brevity in the addresses becomes the rule instead of, as now, the exception. Similarly, we may dismiss the prediction ventured by one speaker in the debate, that the new system will discourage the sending of telegrams, and may result in a diminution of their number. He arrived at this, apparently, by having discovered that under the new tariff a long telegram may, and indeed often will, cost more than under the old. Just so; the essence of this reform is to discourage long telegrams, and to encourage short ones. The boon will be in the permission to send a telegram for sixpence, whereas now a telegram can be sent only at the cost of a shilling; and this boon is so large and so valuable in itself that the contingent extra charge for telegrams of exceptional proportions may be disregarded altogether.

On this point Mr. Lefevre's statement has not had justice done to it. His critics all dwell exclusively upon the acknowledged waste of words in the addresses, whereas he pointed out that the same extravagance commonly prevails in the message itself. It is, in fact, notorious that in a large proportion of telegrams the permissible maximum, not the possible maximum, is before our eyes, and we carelessly avail ourselves of the wasteful privilege. One London newspaper eloquently declares that the public demand that they shall enjoy telegraphy at least as cheaply as it is to be had in other countries. The fact is that this is precisely what we are to enjoy next August if we may. In all other countries the addresses, we believe, have never been transmitted free, but have formed part of the message as a whole. It is this fact that has enabled Continental telegraph administrations to be beforehand with us in cheapening their rates, the free addresses in this country causing the prime cost of transmission to be exceptionally high. The maximum of twenty words for the text was too high to begin with, and the addresses being unlimited made matters worse; so that the English telegraph system, ever since the rate was reduced to a uniform shilling, has never had a fair chance of being remunerative; and to reduce the charge on the same footing, or anything like the same footing now, would be simply ruinous. If the existing system were a real privilege, something might be said for its retention even at a financial sacrifice; but all authorities in this country are agreed, and the experience of Continental administrations bears them out, that a comparatively low maximum will occasion no inconvenience, and that a higher one is downright waste. There is a wide difference between a tariff of twelve words and one with an average of twenty-seven. But so there is between six pennies and twelve; and when it is known that the general run of messages, with their addresses, might be reduced by half, or nearly half, without any hardship at all, the balance of advantage to the public in being able to send a short message for the smaller sum must be held to outweigh the trouble of cutting down superfluous verbiage in the message, and elaborated courtesies in the addresses.

As to the alleged hardship to the working classes who have long addresses, their short messages will make amends for that.

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The picture of the working man being "deterred" from sending a telegram for sixpence now that the addresses are to be charged for is something too ridiculous even for a sentimental Parliament to weep over. We don't much believe in this new patron of the telegraphs; but supposing he turns up, he will find his advantage, like other people, in being able to send a message for half what it would cost him now if he chooses to cut it short. Mr. Shaw-Lefevre has wisely helped him in this matter by adopting the Continental practice of allowing five figures to count as one word, and compound words in the addresses to be treated in a similarly liberal spirit. These concessions, especially the one relating to figures, have been too little noticed. They will in effect expand the maximum by at least one or two words in almost every case; and in commercial messages, where figures are of frequent occurrence, the advantage will be even greater. If the critics of the Bill are not satisfied with this, the responsibility of losing it altogether should be thrown upon them. Those who complain of the anomalous effect on long telegrams under the proposed tariff should be reminded that a far greater anomaly prevails in respect to short telegrams under the existing tariff. One person may send forty words for no more than a shilling, whilst another person has to pay half as much again, or more, for fewer than thirty if the excess happens to be in the message and not in the addresses. This is not merely an anomaly; it is an injustice—to the department in the one instance, to the public in the other; and it can only be remedied by taxing the despatch as a whole.

CORRESPONDENCE.

NEW ELECTRICAL EXPERIMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: While experimenting with vacuum tubes on the 23rd inst. I observed a phenomenon which I have seen no published account of. The source of electricity used was a coil machine, the primary coil being excited by a battery. Having by the means of a small insulated gas flame determined the direction in which the current of electricity was passing between the terminals of the secondary coil, I applied the plus or electricity-giving terminal of the coil to the right arm of a V-shaped vacuum tube, and the minus or exit-terminal of the current I attached to the left-hand terminal of the V tube. As seen in the dark the right hand arm of the tube was full of pink coloured rays of light extending from the platinum terminal at the top of the arm down to nearly the bottom, but not to the very bottom of that half of the tube; the pink rays of light stopped at a horizontal line parallel with the upper edge of the bent part of the tube. The left arm of the tube was filled with a greenish-yellow light, which extended round the turn at the bottom of the tube until it met the horizontal line of pink light in the right arm of the tube. The greenish-yellow light filled all the left arm of the tube, except a small inverted pyramid of pink light which was attached to the under side of the platinum disc, which forms the inner end of the terminal of the tube. This small inverted pyramid of pink light was evidently kept in existence by particles of the pink light coming from the right arm of the tube, but these particles of pink light were invisible as they passed up through the greenish-yellow light in the left arm of the tube. It was only on their arriving close to the platinum disc that they became visible as they rushed against it. This state of matters led me to think that a change would take place if I inverted the tube, and used it like a letter Λ instead of a V. Having inverted the tube, I passed the electricity through it in the same direction as before. The right arm of the tube was again filled with rays of pink light, which now turned the corner of the tube and descended into the left arm, filling it also with the pink light. From this it was manifest that either the magnetism of the earth or the attraction of gravitation had been the cause why the pink light did not freely ascend into the left arm of the tube when it was used like a letter V. To determine this question I made the following experiment with a straight vacuum tube, 13½in. in length between the inside terminals and ¾ of an inch in diameter, and having at one end of it a small chamber for holding potash, so that when the latter is heated the vacuum may be partially destroyed. When this tube has been undisturbed for some days, and then electricity passed through it, throughout the length of it there is nothing visible but the greenish-yellow light, similar to that which is seen in the V tube. But after the potash has been heated the tube is filled with striæ of pink light. When about to make the following experiment, I first tested the straight tube with electricity while it lay in a horizontal position, and found that it had not had time to fall back into the state of greenish-yellow light since the time I had previously heated the potash. There were still in the tube striæ of pink light, which extended from the end by which the electricity was admitted to the tube to within 3½in. of the outlet terminal. I now placed the tube in a perpendicular position, and admitted the electricity to it, so that the current went in by the bottom terminal and went out at the top one. While thus arranged the pink light extended from the bottom terminal to within 3½in. of the top of the tube. These 3½in. were filled with greenish yellow light, and this part of the tube was quite transparent. The pink striæ in the lower part of the tube were well defined, being much flattened spheres, and the highest of these striæ was so flat on the top that there was a well defined line between it and the greenish yellow light above. I now reversed the current of electricity, making it to descend through the tube. Immediately the whole appearance was changed. The great mass of the pink light was now at the top of the tube, and the 3½in. of greenish light at the bottom of it, with this very marked difference, that the pink striæ were no longer well defined—they seemed to run into one another, and there was no defined line between the pink striæ and the 3½in. of greenish yellow light at the bottom of the tube, and the latter was no longer transparent; the pink particles were seen descending through the greenish-yellow light. From these facts it is manifest that gravitation must be the force operating on the pink particles of potash, which, as far as known, are not acted upon by the earth's magnetism.

These experiments prove that the plus or inlet terminal of the current of electricity exerts the greatest amount of force in controlling the potash matter. Now, this is opposed to the statement of Mr. Crookes that the minus or negative terminal of these tubes exercises the most influence over the matter within them.

The tubes I have were made by the same party who made tubes for Mr. Crookes.—Yours, &c.,

JAMES JOHNSTONE.

8, Dalhousie-terrace, Edinburgh, 25th May, 1885.

ELECTRIC LIGHTING IN MILAN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In a note from the *Tecnomasia Italiano* of Milan, published in your issue of 22nd inst., we observe several misleading statements which we would respectfully request you to rectify.

The Teatro alla Scala at Milan is, and has been since December, 1883, lighted by 2,546 Edison lamps, fed from the Edison Central Station in Via S. Radegonda, and operated by the Società Generale Italiana di Elettricità, Sistema Edison.

The installation at La Scala forms part of the general network of conductors parting from said Central Station, which has at present connected with it 5,600 Edison lamps, and seven Siemens arc lamps.

The arc lighting referred to by your correspondents was a provisory installation, consisting of a portable engine and a Gramme dynamo, feeding six arc lamps, with hand regulators,

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which were used only for special scenic effects during ballet performances.

In fact, as a result of experiments made by our engineers at La Scala during the past season with arc lamps fed from the incandescent circuits of the theatre, this company has been requested in the future to furnish also these arc lights.

As noted above, we have seven Siemens arc lamps in regular operation on our incandescent circuits, which give great satisfaction to the consumers. Hoping you will accord the same publicity to our corrections as you gave to the article in question, we remain, yours, &c.,

SOCIETA' GENERALE ITALIANA DI ELETTRICITA', SISTEMA EDISON, L'Amministratore Delegato, G. COLOMBO.

Milano, May 25, 1885.

ELECTRICAL CONDITION v. RECENT SCIENCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The letter of your correspondent, "S. E. R.," surprises me. Surely a reference to any of the thousand-and-one text-books of electricity published during the last twenty years would have supplied him with all the information he can desire.—Yours, &c., S. E.

ON OBSERVING AND RECORDING THE VARIATIONS OF A CURRENT.

BY C. W. S. CRAWLEY AND F. B. O. HAWES.

The authors have for some time past had occasion to observe and obtain a permanent record of the variations of certain currents, these variations being continuous and sometimes large, at other times very small compared to the total current. The method employed may, they think, be of use in similar work, such as earth currents, &c., the apparatus used having the advantage of being easily and cheaply constructed.

The measuring instrument employed was a non-astatic mirror galvanometer.

The first method adopted was using an ordinary scale for taking the readings of the galvanometer. One observer watched the scale, calling out the numbers to which the spot moved every time the current varied, a second immediately called the time, while a third recorded the two together in a book. This method required at least three observers, and was found quite unsuitable for quickly varying currents.

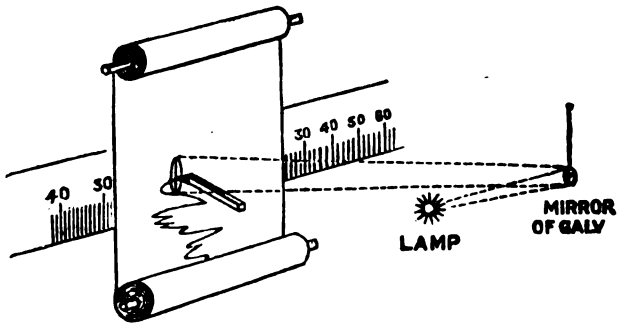

FIG. 1.

This was improved by the observer who read the scale having a key, which he depressed every time he called a number, *i.e.*, every time the current varied. The key worked an electric pencil, which made a mark on a moving Morse strip. Alongside the first pencil was a second one, in connection with a clock which sent a current every half minute, and thus made half minute marks on the same strip.

Only the numbers called had thus to be taken down, the times being afterwards determined from the dots on the Morse strip. In both these methods curves were afterwards plotted out from the data obtained; they were, however, found to be not sufficiently accurate, as there was occasionally a difficulty in determining the time, and in addition the curves did not show the speed of the increase or decrease of a current.

The following method was therefore finally adopted, by which very quickly varying currents were accurately recorded for hours at a time, only one observer being required, and the labour of plotting the curves afterwards being avoided.

Suppose a continuous sheet of paper were moved vertically across the scale of the galvanometer at a uniform speed, and the spot of light were followed by a pencil in its movements along the scale (Fig. 1), the result would be a continuous curve, showing every change of current. This would, of course, be impracticable, as the hand would be continually between the galvanometer and the paper, thus intercepting the spot of light; but by using a mirror, M, as in Fig. 2, the light may be reflected on to a sheet of paper moving horizontally across a table, when the curve may be conveniently traced.

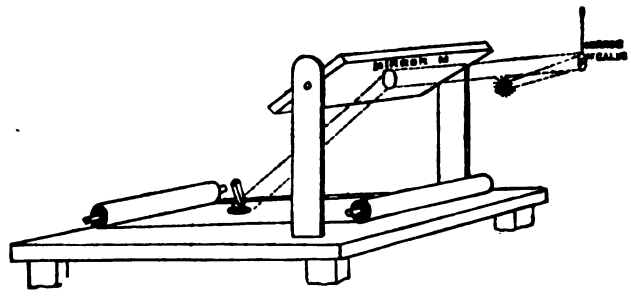

FIG. 2.

The paper was wound off one roller on to another, the former having an adjustable break on it, to keep the paper taut; and the latter being rotated by means of an endless cord and weight, so arranged that the weight might be pulled up without stopping the movement of the paper.

In Fig. 3 A is the roller carrying the paper, B and C weights of 10 and 1lb. respectively, and D a ratchet or clutch pulley, the driving weight B being raised by pulling the right hand cord, as shown by the arrow.

The roller A is also connected by an endless cord to a small pulley on the axle of an escapement wheel, controlled by a heavy pendulum, and, by altering the size of this pulley, any desired speed may be given to the paper. The speed generally used for earth currents was about three meters an hour.

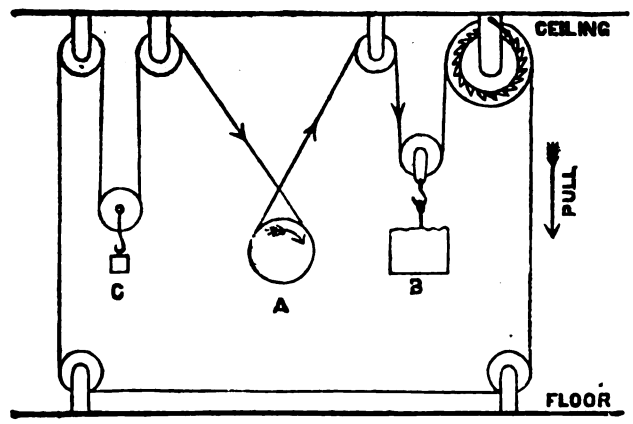

FIG. 3.

The spot of light was followed by a pencil, working against a brass bar (not shown) fixed across the paper at right angles to the line of motion, the centre of the spot being made to fall at the front edge of the bar by adjustment of the mirror *m* (Fig. 2). Close to the edge of the paper is another pencil (not shown) fixed on a spring, and working against the same brass bar, with which a mark was made every minute; it would be worked either by the left hand, by foot, or automatically by a clock.

When taking a curve the position of the spot of light when at zero was first marked on the paper, and such data as the time of swing, constant of galvanometer, exact hour and minute of starting, &c., noted down for future reference. Zero was also taken every quarter of an hour throughout the readings, both to facilitate the drawing of the zero line when the curve was

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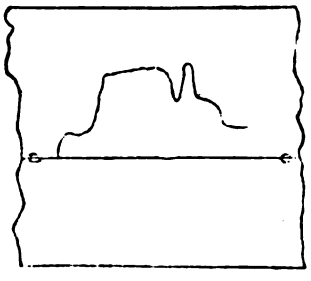
finished, and to avoid any error due to slow shifting of zero from torsion of the fibre or other cause. The amount of curve lost in this latter operation was very small, it being done with practice in less than ten seconds.

The swinging of the needle caused some trouble at first. Thus, say Fig. 4 is the curve representing the true variations of the current, if the swings were unchecked it would give a curve somewhat like Fig. 5, and to find the true variations it would have to be replotted. This, besides taking time, would be liable to introduce errors, as it would be difficult to distinguish between the swings and the true variations.

FIG. 4.



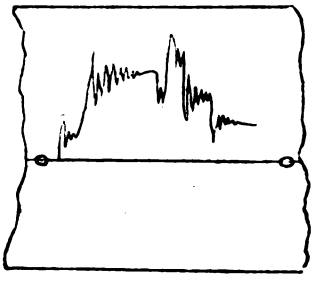


FIG. 5.

To overcome this inconvenience a coil of about fifty turns of wire was placed at a short distance behind the galvanometer, and joined up with a Leclanché cell through a double reversing or commutator key (Fig. 6) with two bottom contact pieces instead of one, as in an ordinary double key.

By depressing the right hand key the spot may be deflected to the right, and *vice versâ*.

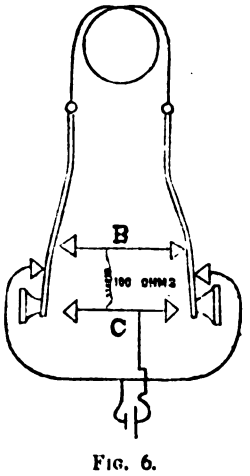


FIG. 6.

The use of the two bottom contacts is as follows:—When one of the keys is depressed, it first makes contact with the back contact piece B; the current then passes to the coil through a resistance of about 100 ohms (a couple of yards of 3 mil. G.S. wire). When, however, it is fully depressed it makes contact with the front piece C, and the full current is sent through the coil, the effect on the needle being then about twenty times as strong as when the key is half depressed. Now, supposing a steady current switched on to the galvanometer, sending the spot to the left, the right hand key must be depressed for a sufficient length of time to "break the swing," so that the spot may stop short at the point at which it would have finally settled down had it been allowed to continue swinging till it came to rest of its own accord. If the current is a strong one (or in the case of a varying current, if a variation be large) giving a considerable swing to the needle, the key is depressed to the front contact; but, if it be small, the key is only half depressed, using the back contact.

This method, it may be urged, tends to introduce errors, but it is not found to do so; for, with practice, the spot can be brought to rest at once at the right point, the speed at which it moves being the guide to the position at which it should be brought to rest.

This "swing check" has also been found to effect a very large saving of time in condenser and similar work, in which, after taking one reading the spot must return to zero before the next one is taken. It is also found useful in Mance's method for finding internal resistance, for the final readings in bridge work, &c.

(To be continued.)

ON THE SEAT OF THE ELECTROMOTIVE FORCES IN THE VOLTAIC CELL.*

BY PROFESSOR OLIVER J. LODGE, D.SC.

(Continued from page 30.)

CHAPTER V.—*Suggestive.*

25. Discussion of Sir William Thomson's contact-electricity limit to the size of atoms, from the new standpoint.
26. Suggested mode of ascertaining the heat of formation of brass or other alloy.
27. Attempt to determine size of atoms from heats of amalgamation and thermoelectric data. Possible mode of measuring latent heats of liquefaction for metals at ordinary temperatures.
28. Consideration of limit of thinness of a metal sheet exposed to air, and estimate of molecular dimensions therefrom.

Size of Atoms.

25. I may now claim to have accomplished my task; and terminate this long paper; but there are several interesting points which arise in connection with Sir W. Thomson's deduction of a limit to the smallness of atoms from contact data, and these I may be permitted to indicate. Indeed it evidently becomes a question whether or not his argument remains quite valid if the chemical-strain view be taken of Volta's force.

Let us then inquire whether any modification has to be made in Sir Wm. Thomson's argument, if the hypothesis set forth in this paper be adopted. He says (virtually), Take a number of plates of zinc and copper of specified thickness, arrange them alternately like the leaves of a book with the covers doubled right back, and then shut the book. Directly they touched at one edge they became oppositely electrified and attracted each other, and therefore did work as they approached. By making the leaves numerous and thin enough, and shutting them up close enough, any required amount of work can be thus done with given quantities of metal, provided the thin plates retain the same properties as masses of metal possess; *i.e.* provided they are not only a few atoms thick. So far there is no possible objection; but Sir William proceeds to consider the attraction as depending on the affinity of zinc for copper, and the work he requires of his plates is that evolved in the formation of brass. But if we regard the attraction as depending on the difference of combustion energies, Zn/O – Cu/O, we must, to keep the charge constant, not only take the plates several atoms thick, but we must suppose films of air of sufficient thickness to preserve their normal activities in the way of chemical strain to be shut up with the plates. Given these, the amount of work he has calculated would certainly be done in shutting the book, and a corresponding amount of heat generated. But would this heat have anything to do with the making of brass? So far as I can see, nothing whatever.

If we intend to make brass, must we not regard the air surrounding the plates as a simple accident, and imagine all air-films removed before beginning the operation? Work with the zinc and copper plates in absolute vacuum, where (on my hypothesis at any rate) the only difference of potential between them is a minute thermoelectric one; there will be an attraction caused by this difference of potential, and work will be done in shutting the book, but to get any appreciable amount of heat the plates must be terribly thin. How much heat really is produced in the formation of brass I don't believe any one knows; but if it be enough to warm the metals sixty degrees, the lower limit to the size of atoms becomes greatly depressed.

In a note near the end of this paper I show that a rise of from ½ to 2 degrees is all that is probable, on the usual estimate of atomic dimensions;

* Reprinted from the *Phil. Mag.* for May.

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the smaller evolution of heat being caused by alloying the metals at 10° C., the larger being produced by alloying them at 400° C.

26. *Is* there much heat produced in the formation of brass? Is there any way of attacking the question simply? The only way which has occurred* to me is to dissolve brass in acid, and to see whether one gets appreciably less heat than by dissolving its constituent copper and zinc separately. When an alloy is dissolved, I suppose the affinities of its constituents are unloosed, or the combination undone; hence the heat developed during the solution of an alloy, subtracted from that produced during the solution of its constituent metals and mixing of those solutions, ought to measure the heat of formation of the alloy. Dr. Forster Morley, of University College, London (also on the boat), said he might be willing to undertake this observation, which is doubtless a delicate one, for he was engaged in some thermo-chemical researches. It may not be practicable for the actual case of brass, because of the complication and uncertainty introduced by secondary products, but a better pair of metals may no doubt be readily found.

Adhering to zinc and copper as convenient for explanation, the argument, though obviously not the order of experiment, will stand as follows:—Take definite weights of zinc and copper, dissolve them separately, getting heats H_1 and H_2 respectively; then mix the solutions, getting a possible further heat-production h. This is one plan of passing from separate zinc and copper to a solution of a salt of brass.

Next take the same weights of zinc and copper as before and alloy them, getting heat H; then dissolve the brass in the same acid as before, getting heat H_3. This is another plan of passing from separate zinc and copper to a solution of a salt of brass.

Now, unless external work and secondary products are different in the two cases, we are justified in writing the heats evolved in the two cases equal:—

$$H_1 + H_2 + h = H + H_3.$$

H is the unknown quantity to be determined, and its determination involves four separate measurements, H_1, H_2, H_3, h.

The only one of these at all easy to observe is h, and this my assistant, Mr. Butler, has done. Proportions of zinc and copper sulphate, containing equal weights of zinc and copper, are dissolved in as little water as will keep in solution any double salt that may be formed on mixing. The zinc sulphate is enclosed in a thin bulb or tube inside the other solution, and left, screened from stray heat, for some hours. The bulb is then broken, or the liquid otherwise blown out of it, and the liquids mixed. No certain change of temperature so great as a hundredth of a degree has been observed.

27. In thinking over what metals were more suitable, it struck me that the heat of formation of amalgams was a subject easy of direct attack. I therefore, as a preliminary, have dissolved a little granulated tin in mercury. Of course the latent heat of liquefaction of tin has to be allowed for, and the actually observed result is a cooling; but I hoped that the cooling observed would be less than what the latent heat would account for, and that I might then calculate the real evolution of heat due to combination. Unfortunately the only data I know of with reference to the latent heat of tin relate to its ordinary melting point, at which point it is given by Rudberg as 13·3, and by Person as 14·25. We have no ground whatever for believing latent heat to be constant, and I am therefore utterly in the dark as to what the latent heat of tin at ordinary temperatures may be. That liquid tin could be super-cooled to ordinary temperatures without solidification is unlikely. I give, however, the data of my experiment (which was carefully performed) in case better latent-heat data are known to some one else:—2·10 grammes of thin granulated tin at 12°·4 were dropped into 502·00 grammes of mercury at a steady temperature of 10°·85, contained in a large thin protected test-tube, of which the part sharing the temperature of the mercury weighed 8 grammes. After solution, which took ten minutes, the resulting temperature was found to be 8°·82. Three minutes later it had risen to 8·99 from surrounding influences. The thermal capacity of the immersed part of the thermo meter was equivalent to ·48 gramme of water.

Working on these data, and taking the specific heat of tin as ·056, latent heat 14·25, specific heat of glass ·19, and of mercury ·033, we find:—

Heat disposed of in cooling and liquefying tin ..... 30·45 units.
Disappearance of heat actually observed ..... 43·57 ,,

More than can be accounted for without any combination-heat at all! This is rather depressing; but it only shows how wrong is the estimate of 14·25 for the latent heat of liquid tin at 10° C.

Ignorance of the true latent heat thus effectually prevents our obtaining any information whatever, about the heat of combination of tin and mercury, from the experiment. It seems, indeed, easier to observe the combination-heat by a process of dissolving the amalgam and the metals separately in acid, as already explained for brass, and then to use the above experiment to calculate latent heat from. One might perhaps thus get the latent heats of fusion at various temperatures for metals soluble in mercury.

Another alternative, however, presents itself. Instead of trying to reduce the latent heat to ordinary temperatures, one might form the amalgam at a temperature just below the melting-point of tin, and obtain, if possible, the net evolution of heat then.

Suppose the heat of combination of the 2·1 grammes of tin with mercury to be somehow or other determined, we have next to suppose the amalgam made otherwise, bringing the molecules together in a reasoned way. Let the same quantity of tin be brought to within molecular distance of the mercury in successive pieces of very thin foil, first made to touch at one corner and then laid down.

* It occurred in conversation with Prof. S. P. Thompson and Dr. J. A. Fleming on board the Quebec excursion steamer 'Canada,' and I am unable to say who suggested it.

It is quite true that each flake would be charged with a Volta E.M.F. of, say, ·6 volt, and so would attract the mercury and do a certain amount of work in laying itself down. But it is not fair to compare an operation thus conducted in air with the dropping of a solid mass of tin into mercury: to be able to compare the two operations, one must perform the foil experiment in absolute vacuum. This being done, the contact E.M.F. is no longer ·6 volt, but only about ·00015 volt according to the experiments of Matthiessen. Good data for this quantity are, however, wanting. Mercury is not one of the metals included in Prof. Tait's series. It was observed by Gaugain; and by rather hypothetical deduction from his numbers, as given pictorially in Wiedemann's *Elektricität*, I make the tin-mercury Peltier force 1·75 millivolt at 10°*.

Taking one of these numbers (15,000 or 175,000 in C.G.S. units), or a better one when determined, we can calculate how near the given mass of tin must be brought to the mercury in order to generate the actual heat of combination, provided one knows the specific inductive capacity of absolute vacuum†. But I do not know it. Thus the supply of data for this case is distinctly unsatisfactory.

28. Let us try whether we cannot do better with a single metal exposed to air, not troubling about the contact of two metals, which is unnecessary, but simply considering one metal in contact with air.

Take a gramme-equivalent of any metal, say 65 grammes of zinc, and imagine it rolled out into a thin sheet of foil of area A. The difference of potential between it and the air being V in electrostatic units, $\frac{V}{300}$ in volts, its charge will be $\frac{2AV}{4\pi x}$, where x is the distance between it and the air, a quantity of molecular magnitude. The electrical energy of this charge is $\frac{AV^2}{2\pi x}$, which must therefore have been the electrical work done (*i.e.*, the amount of potential chemical energy transmuted into electrostatic energy) in spreading out the zinc over so much surface. [Capillary tension is part of the *mechanical* work done.]

Now let it be rolled so thin that every atom of it is in contact with air, *i.e.*, let its thickness be also of molecular magnitude x. We can regard its potential energy in two ways: either as chemical or as electrical. Chemically its energy, measured by heat of combination, is

$$46{,}000\ VJ,$$

where V is expressed in volts. Electrostatically its energy is

$$\frac{A}{2\pi x} \cdot \left(\frac{V}{300}\right)^2.$$

Equating these two values, and writing for the quantity of metal $m = Ax\rho$, we have the general relation

$$mV = \cdot 828\ \pi\ \rho\ x^2\ J \times 10^{10};$$

whence, taking $m = 65$, $\rho = 7$, and $V = 1 \cdot 8$, we get as our estimate of linear molecular dimensions,

$$x = 4 \times 10^{-9}.$$

The data in this calculation are all very definite; hence, if the reasoning is legitimate, this estimate ought to be a pretty good one. It is true that another metal would give a rather different estimate, unless $\frac{mV}{\rho}$ were constant for all; but for ordinary methods—*e.g.* zinc, iron, copper,

* Since this was in type a paper by C. L. Weber has appeared in Wiedemann's *Annalem* for November, 1884, on the thermoelectric properties of amalgams, in which mercury itself was examined; and from the data there recorded, together with Tait's value for copper, I reckon the thermoelectric value of mercury at t° C. as

$$431 + \cdot 5t \text{ absolute electromagnetic units.}$$

Whence the Peltier force at the same temperature is

$$1181 + 5 \cdot 68t + \cdot 005t^2 \text{ microvolts.}$$

The Peltier force between tin and mercury at 10° is therefore 123,800 absolute units, or 1·24 millivolt, which agrees well enough with the rough estimate above.

† Taking this as 1, and assuming the estimate of molecular dimensions hereafter established, and working backwards, one can show that the Peltier force of tin and mercury at 10° is connected with the heat of combination of our 2·1 grammes of tin with the 502 grammes of mercury by the relation

$$J\Pi = 3 \cdot 6 \times 10^6 \sqrt{H}.$$

The two rough estimates of $J\Pi$ deduced from Matthiessen and Gaugain respectively (15,000 and 175,000) thus give H as about $\frac{1}{4}$ and $\frac{1}{18}$ of a unit respectively. Either of these is too small a quantity to be observed in the process of dissolving tin in mercury; so neglecting it we get, from that experiment, the latent heat of molten tin at 10° C as 20·4. Another experiment made in a similar way gave 19·6.

If the above reasoning be regarded as legitimate, a combination of thermoelectric measurements with observed heats of solution in mercury may furnish a means of estimating latent heats of fusion at various low temperatures in general.

Working back similarly to the heat of combination of 1 gramme of copper with 1 gramme of zinc, we calculate ·077 unit as the heat developed at ordinary temperatures; only enough to raise the mass of brass formed through three eighths of a degree Centigrade. At a higher temperature, such as 400° C., the Peltier force for these metals is greater, being 4600 microvolts, and the calculated heat of combination is then $\frac{1}{2}$ of a unit per gramme of each, sufficient to raise the whole mass of metal through nearly 2 degrees Centigrade. This, then, is the sort of elevation of temperature one may expect in making brass at a temperature of 400°.

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mercury, silver—this is not so outrageously far from being the case; though discrepancies arise with such metals as sodium on the one hand, and platinum on the other. But it is very doubtful whether platinum could be regarded as an oxide, however thin it were beaten; and sodium would probably take fire long before the proper molecular thinness was reached.

The several estimates of Sir William Thomson for the size of atoms were given in 'Nature,' March 1870, and are reproduced in Thomson and Tait, Part II., Appendix F. In a lecture on the size of atoms delivered at the Royal Institution in February, 1883, he restates these estimates with slight modifications thus:—

If atomic dimensions are comparable with 10^{-8} centim., brass would rise 62° C. at the instant of formation; while if atoms are so small as $2{\cdot}5 \times 10^{-9}$, it would rise 1,000° C. Hence 10^{-8} is to be regarded as a limit of smallness.

A soap-film so thin as 10^{-8} centim. would raise itself 280° by collapsing; therefore there are not several molecules in this thickness.

The theory of gaseous collision, combined with the density of liquids, suggests a range lying between 7×10^{-9} and 2×10^{-9}.

The dispersion of light seems to require atomic dimensions to lie between 10^{-7} and 10^{-9}.

The final estimate made by Sir William is something between

$$2 \times 10^{-7} \text{ and } 10^{-9}.$$

But if the reasoning in the present paper be admitted as correct, it would seem possible to reduce this range of uncertainty, and to make an even more precise estimate.

PHYSICAL SOCIETY.—May 23.

Professor Guthrie, President, in the chair.

Dr. A. H. Fison was elected a member of the Society.

The following communications were read:—"Experiments showing the Variations caused by Magnetisation in the length of Iron, Steel, and Nickel Rods," by Mr. Shelford Bidwell. The subject of the extension and retraction of bars of iron and nickel under the action of magnetic force has been investigated by Drs. Joule and A. M. Mayer and by Mr. Barrett. In the present experiments the magnetising force has been increased, with the result of bringing out some striking and novel characteristics. The apparatus employed consisted of a vertical magnetising helix considerably longer than the experimental rod, the latter forming the central portion of a compound rod, the two ends being of brass. The lower end of this rod is plane, and stands on a firm support; the upper end is a knife edge, which bears against a brass lever 18cm. in length, about 1cm. from the fulcrum; the portion of the rod to be examined is in the central portion of the helix. The above lever is furnished with another knife edge at the end which acts in a similar manner on a second lever, at the extremity of which is a small mirror. A lamp and vertical scale being placed at a distance of 470cm. the slightest motion of the mirror could be read with great accuracy, an elongation of the bar amounting to 1/102·000th mm. being easily detected. A few of the more important results are as follow:—In the case of soft iron the bar continually increased in length till nearly saturated, up to which point Mr. Joule had traced it, but then it reached a maximum, decreased, and continued decreasing to the limit of the experiments, at which point the retraction was about double what the extension had been. The effect depended upon the thickness of the bar, an increase of diameter diminishing the maximum extension and increasing the critical magnetising force, or that force which produced the maximum extension. The results seemed to show that this extension varied inversely as the square root of the diameter of the bar. The general behaviour of steel was the same as that of soft iron; but the critical point varied with the hardness and temper of the metal, appearing to be a minimum for steel of yellow temper. The results of experiments upon nickel coincided with those obtained by Prof. Barrett, the effect of magnetisation being to cause a continuous retraction greater than that obtained with soft iron. In answer to Prof. HUGHES, who believed that the effect of the coil was always to produce *retraction* of the bar, the *extension* at first being due to the molecular arrangement of the particles during magnetisation, Mr. Bidwell further described an experiment showing that the action of the coil was to produce the *extension* of a magnet. Two thin strips of soft iron fastened together at the ends, their central portions being about 2cm. apart, were placed in the coil. On making the current the ends were drawn out, the sides coming together. Prof. FORBES suggested that the effect of thickness was really owing to the irregularity of magnetisation produced by the ends, and that in future experiments the middle of the bar only should be examined.

"On the Spectral Image produced by a Slowly Rotating Vacuum Tube," by Mr. Shelford Bidwell.

"Note on the Action of Light in Diminishing the Resistance of Selenium," by Mr. Shelford Bidwell. As the result of their investigation upon the behaviour of selenium, Messrs. Adams and Day arrived at the conclusion that it conducted electrolytically. Since it would necessitate the assumption that selenium is not an element according to accepted theories caution must be exercised in accepting that view. It seemed possible, however, that since the selenium in the cells had always undergone a prolonged cooking in contact with the metal terminals, selenides of these metals might exist in the selenium, forming a kind of network, and thus affording conduction through the mass, which without the cooking is non-conducting. It had not been possible to test this directly, but a somewhat analogous case had been tried. Some precipitated silver had been heated for some hours with sulphur and the clear liquid poured off. A cell was then made by coiling two silver wires side by side upon a strip of mica, the spaces between them being filled with the prepared sulphur, which would contain a small quantity of sulphide of silver. It was found necessary to reduce the resistance of the cell by placing a small strip of silver leaf over the sulphur and cooking it again. The cell thus prepared was very sensitive to light; by burning a piece of magnesium near it, the resistance was reduced to one-third. Mr. CLARK said that Mr. Bidwell's cells probably contained sulphides of copper or silver, substances which the researches of Faraday had shown conducted electrolytically in the solid condition. On the other hand, Cu_2Se and Ag_2Se conducted like metals, and were probably often present in the ordinary selenuim light cells. Mr. Clark thought that Mr. Bidwell's paper raised this question:—What influence had light upon the electrolytic conduction of Cu_2S and Ag_2S, and upon the metallic conduction of Cu_2Se and Ag_2Se?

"On Certain Cases of Electrolytic Decomposition," by Mr. J. W. Clark. The first part of this paper consisted of a critical examination of the behaviour of those substances which have been described as exceptions to Faraday's laws, with the object of generalising as to the condition of internal or molecular structure corresponding to their electrical properties. The second part described an experimental investigation into the nature of the conduction of fused mercuric iodide and mercuric chloride, both of which were stated to undergo electrolytic conduction. Decomposition and recombination of the products of electrolytic action may, however, follow so closely as to simulate metallic conduction. The first product of electrolytic decomposition of mercuric iodide was stated to be iodine and mercuroso-mercuric-iodide (Hg_4I_6), which latter, under the continued action of the current, yields free mercury. Similarly it was found that fused mercuric chloride, when electrolysed between graphite terminals, split up into chlorine and mercurous chloride. Metallic conduction—*i.e.*, conduction without decomposition in fused compound solids, therefore, appears to be unknown.

Note on "Electrical Symbols," by Mr. J. Munro.

SIXPENNY TELEGRAMS.

In the House of Commons on Friday evening last, Mr. Shaw-Lefevre moved the second reading of the Telegraph Acts Amendment Bill.

Mr. W. Lawrence, who had an amendment on the paper to the effect that, if any charge is made for addresses, it should be a fixed one, and not varying with the number of words, figures, or letters, and that such charge should not exceed threepence, said he would not move his amendment, but he hoped that the Postmaster-General would consider the matter during the recess.

Mr. Puleston said he believed that under the Postmaster-General's scheme there would be such a diminution of telegrams that the loss to the revenue would be greater than from free addresses.

Dr. Cameron suggested that in large towns the Post Office authorities should codify the streets. Such a code might be published, either in a separate form or in the "Postal Guide"; if this arrangement were adopted, the address would be got through in one word.

Mr. Shaw-Lefevre said this discussion was only a rehearsal of the debate that would arise on the amendment of the noble lord opposite (Lord J. Manners), and he, therefore, hoped hon. gentlemen would excuse him if he did not now reply to all the points that had been raised. He did not understand the hon. member for the City of London to be opposed to the principle of the Bill, but only to propose an alternative plan. When in Committtee he should be happy to consider fully any amendments that might be brought forward provided they did not involve a greater burden on the Telegraph Department than the plan laid down in the Bill. It had been urged that the Post Office and the telegraph business should be considered as one, and that the profits of the one might very fairly be applied to cover the loss on the other—that any loss in the Telegraphic Department ought to be recouped by the profits of the Post Office. That was a principle that had never been recognised by that House. Since the purchase of the telegraphs it had been well understood that the Telegraph Department should be treated by itself, and that, as far as possible, it should be made self-supporting after paying reasonable interest on the purchase money paid for the acquirement of the telegraphs. He thought that a sound principle, and was not prepared to depart from it. It would not be right or fair that the general public should be taxed in order that a small part of the community should be able to send their telegrams at a price much less than the cost price. The telegraph service was not now in so flourishing a condition as it was two years ago. Owing to the increase of remuneration paid to the *employés*, and also to the competition with the telephone, there had been a great reduction in the profits of the telegraph service. They had fallen from £450,000 to at the outside £250,000 a year, and out of this £250,000 there remained to be paid the interest on the £11,000,000 which was paid for the purchase of the telegraphs, and this reduced the interest to a very low rate. The plan that he now proposed had been carefully worked out by experts in the Post Office, and it was calculated that, allowing for an increase of 30 per cent. in the number of messages sent, there would during the first year be a reduction of the Telegraph Department profits by about £180,000, and this would reduce the profits to £70,000 a year, which was a very small margin of profit on a business of such magnitude. The reduction of the price of telegrams from 1s. to 6d. really involved a much larger financial risk than most persons supposed. There were certain expenses connected with telegrams which were incurred whatever the length of the telegram—such as the receipt of the telegram over the counter and its delivery within the radius. It had been estimated that the average necessary cost of each telegram, irrespective of its length, was 2½d., and that left the price charged now and to be charged under this Bill 9½d. and 3½d. respectively, and therefore the proposed reduction was really about one third. Every telegram was accompanied

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by certain official words, eight in number, necessary for the purposes of information to the department. The average length of addresses had been found to be 11 words, and therefore the average length of an ordinary message under present circumstances was 39 words—the message 20 words, the address 11, and the official words 8. The Bill proposed to reduce the number of words to 20—namely, 12 words in the message and address, and the eight official words; the length of the message would be reduced from 39 words to 20 words, or one-half, while the price was being reduced from 9½d. to 3½d. It was accordingly neceessary that there should be some economy of work. It was well known that there was an enormous waste of words in the sending of telegrams, and an amount of useless labour was thus thrown on the department. A large number of telegrams had been carefully examined, and it was found that the number of superfluous words amounted to about 25 or 30 per cent., and a large proportion of the superfluous words occurred, it was found, in the addresses. These, on an average, now consisted of eleven words, and it was the opinion of competent persons that the address as a rule need not occupy more than five words. A saving of six words could thus be effected in each telegram, which was estimated to amount in the year to about £200,000. He quite admitted that free addresses had some convenience, but on the other hand they were a very expensive luxury, as they cost the service £200,000 a year. He had observed in the newspapers various alternative suggestions to his proposal. They all resulted in loss to the department. The hon. member for the City of London who last spoke proposed that a free address and ten words should be given for 6d. He had had the cost of that calculated. It showed that, assuming an increase in the number of telegrams sent in consequence of the reduced tariff to the extent of 30 per cent., the loss to the service would be £560,000 a year. That was not the worst part of the case, for a tariff of that kind would enormously stimulate business and would greatly increase the working expenses. They believed that it would be impossible to send free addresses and ten words for 6d., without in a short time, by reason of the enormous increase of business, incurring a much greater loss than £560,000 a year to the department.

In answer to a question by Mr. Hubbard as to whether he calculated the loss to the department by rule of three, Mr. Shaw-Lefevre said that the figures he had quoted were from calculations made by the officials of the department. The loss from the hon. member's suggestion would be so great, therefore, that a tariff of that kind was altogether out of the question. The suggestion of the hon. member for Devonport, that there should be a free address and six words for 6d., it had been calculated would cause a loss of £110,000 a year more than the proposal submitted. The tariff proposed by the hon. member for the City of London, who spoke first, that a free address and five words should be allowed for 6d., would result, as far as he could make out, although it was somewhat difficult to state the actual cost, in a loss of £100,000 a year more than his proposal. He thought, therefore, that the House would be of opinion with him that these various suggestions were all out of the question without inflicting heavy loss upon the department, and therefore upon the public revenue. The tariff which was proposed under their Bill was a word rate of a halfpenny a word, with a minimum of twelve words for 6d. It was calculated that five words would on the average be used for the address of the message. That was the opinion formed from a careful examination of the existing telegrams by officials of the department. They could not but think that there was a good deal of misunderstanding upon the subject of addresses. The belief had been expressed by the officials that the sender's address would in future average only one word. In support of that view they had before them the experience of foreign telegrams and also telegrams to France and Germany. It was found that foreign telegrams sent to this country in a large majority of cases contained no address at all of the sender. The message itself no doubt showed the receiver from whom it came. A large proportion of the foreign telegrams had only one word to indicate the sender. It was believed that in future, if the proposal of the Bill were adopted, senders would in a very large proportion of cases indicate themselves by one word, and in very few cases would it be necessary to use more than one word. If it were necessary for the sender of the telegram to give a full description of his address, that was information that ought to be contained in the text of the message and ought to be paid for. The hon. member for Salford had quoted the unanimous resolution of the Manchester Chamber of Commerce approving the Bill, and he had asked that in future the suggestion of the Chamber should be adopted—namely, that numbers should be counted as one word, and that where it was necessary the sender's name should be inserted in the address. He was in a position to answer both those questions in the affirmative, and they would in future be the rule. Different words in a number would therefore in future be counted as one word. As regarded the post office to which the message was sent, it was not necessary to put it in the address, because it was always sent for official purposes, and there was no necessity that the sender should put it in as one of the words of the message. While he believed that on an average one word would indicate the sender, a careful examination of telegrams led to the belief that the receiver would be indicated on an average by four words. A large proportion of the foreign messages sent into this country contained only three, and in some cases four, words of address. No great hardship would result if an extra word or two had to be inserted in an address, as the rate would be two words for a penny. The objections which had been raised to this proposal rested mainly on two points. In the first place it was said that the abolition of free addresses would lead to uncertainty and to extra labour on the department; and, secondly, it was said that it would be a hardship on certain classes of persons. As to the first point, the officials in the department did not think that any extra difficulty would be thrown on them, judging by the large experience they had had of foreign telegrams, and also to the fact that, although the addresses in those telegrams were shortened, little confusion or trouble had resulted. There was also the experience of foreign countries to guide them, where a word-rate prevailed. In Germany there was no free address, and it was found that addresses averaged only four words; again, in France a word-rate only existed, and no difficulty was found with respect to the address. The other objection, that this proposal would press hardly on certain classes of people, in this country, was one into which he went at some length in introducing the Bill. With some difficulty he had obtained a number of telegrams sent by working people, and although it appeared that their addresses averaged somewhat longer than those of other telegrams, it was found that about 60 per cent. would admit of curtailments of the addresses without any trouble or difficulty being occasioned. It had been pointed out that the proposed tariff did not look so favourable as the present tariff. By the present tariff 20 words were allowed for 1s., with a free address, whereas under this proposal 24 words would be allowed for 1s., with no free address. But the higher they went in the tariff the more favourable it appeared, and, moreover, it should be recollected that between 6d. and 1s. there were several steps. It was assumed that there would be only the 6d. and 1s. rate, and nothing between; but that was not the case, and any number of words between 12 and 24 would be inserted in the message at 1d. for two words. They believed that a very large proportion of the messages sent—about 30 or 40 per cent.—would be at the 6d. rate. But they also thought that a very large proportion would be sent the cost of which would be between 6d. and 1s. They thought that under the proposed tariff not more than one telegram out of ten would be sent at the 1s. rate. Before resuming his seat he wished to say that to his knowledge no important commercial body had petitioned against the Bill, while, on the other hand, the Associated Chambers of Commerce and the Chambers of Commerce of Manchester and Glasgow, and of other large towns, had spoken of the tariff proposed as one very favourable to the working classes. He trusted that the House would not reject the boon that he was able to offer to the country. He should be perfectly ready to consider in Committee any alternative tariff that might be suggested which would not impose a greater burden on the finances of the department, but he should not be able to agree to any tariff which would have that effect, for such a tariff could not be established without infringing on the principles that the telegraphic service should be independent of the postal service, and that it should be conducted so as to return a respectable profit on the amount invested by the State.

In the course of the discussion which followed Mr. Hubbard observed that when the State originally undertook the management of the telegraph service the receipts improved to such an extent that two years ago the surplus revenue amounted to 3 per cent. on the £10,000,000 which had been invested. Mr. Ruston said an instance of the way in which free addressing might be abused had recently come under his notice. A telegram was sent to him in which the addresses occupied twenty words, and eight of the words in the sender's address ought certainly to have been placed in the body of the message. He strongly approved the proposal that four or five figures should be included in the body of a message as one word. This change, if agreed to, would be an immense boon.

Mr. Warton thought that all sorts of dangerous telegrams might be sent under the scheme without any means of identifying the sender.

Mr. Tomlinson remarked that it was his firm belief, founded upon observation not so much in London as in the provinces, that the telephone would come in time more and more in competition with the telegraph. At all events, so far as commercial telegrams were concerned, there could be no doubt that the telegraph would give place to the telephone, and possibly the large increase which was expected in the telegraph business might not result.

The Bill was eventually read a second time, and the Committee stage fixed for the 4th of June.

COMPANIES' MEETINGS.

The Consolidated Telephone Construction and Maintenance Company (Limited).

The fourth ordinary general meeting of the Consolidated Telephone Construction and Maintenance Company was held at the Terminus Hotel, Cannon-street, on the 26th inst., under the presidency of Mr. C. L. W. FitzGerald.

The SECRETARY (Mr. Charles Curtoys) read the notice convening the meeting and the minutes of the last meeting.

The CHAIRMAN said: The present Board have done their best to submit as intelligible a balance sheet as they possibly could. You are all aware that the accounts are rather complicated, and it has cost us no little labour and trouble to reduce them to something which, I think, we may fairly say one can understand. I should like to point out a few things in the balance sheet and the revenue account. First of all, you will see that the capital has been reduced according to the resolution of the meeting in December last. You will see on the other side an item "subsidiary companies," with an asterisk standing against it—£47,000. That item will be expunged when we hold the next meeting, and in its place will appear £31,500 of 5 per cent. debentures of the Telephone Company of Austria, and £20,000 of 5 per cent. preference shares of the Edison-Gower-Bell Telephone Company. I may say safely that both the interest on these debentures and the preference shares will be paid, and therefore you will receive money from that source. We have separated the ordinary debtors of the Company from the amounts owed by subsidiary companies, and that amount of £4,394 is from companies in England and one or two other companies. Our principal debtor really is the United Telephone Company. We should have been

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very much gratified, indeed, had we been able to pay you a dividend, but the fact of the matter is that the requirements of this business are so vast that I think it would be undesirable, when we have just rescued this Company, practically, out of the Bankruptcy Court, to divide up the profit we have made. If you turn to the revenue account you will see that the manufacturing profit was £8,300. After deducting certain expenses and writing off from that profit £1,500 against goodwill and patent rights, we have a balance of £5,200 to credit of profit and loss. I can point out to you a mode of paying a dividend if it pleases you to do so—that is by the shareholders of this Company purchasing from the Company the £14,000 River Plate debentures standing to the credit of our securities. I am informed by the auditor they are available for sale and division among you as a profit to the extent of, say, £5,000. If this course is not taken, I think it would be undesirable to divide up the profit we have made, for I should point out to you that our business is not alone manufacturing. We have three very important businesses abroad. When I say "we," I mean you have shares in subsidiary companies, each of which has a large and widely extending business. If we do not support those subsidiary companies you would find that our business in the future, when the term of the patents expires, would diminish very much. I have always got my eyes fixed on that point, and feel that we must get a large proportion of our profits from the income to be derived from the exchanges abroad—in other words, from the River Plate Telephone Company, the Austrian Telephone Company, and the Edison-Gower-Bell Telephone Company in Portugal. In the revenue account there is an item legal expenses, and we shall not have to incur a gigantic sum like that again. In reality £1,150 has been paid. A certain sum was reserved from last year's accounts for legal charges, but it has fallen to the lot of this Board to provide the money to pay it. There is also an item of expenses for the committee of investigation (£260), and we shall not have to pay that again. I hope, therefore, that the debit side of the account at our next meeting will be more favourable. I feel myself that it will be, and I mean to do my very best to reduce the expenses in every possible way that I can. Our having had several meetings this year has also added very considerably to the expenses of printing and stationery. As to the subject of manufacturing, I am very happy to say, as to home manufacturing that we are doing a large and increasing business, and I believe, so far as we can judge, that that business will increase more and more. Our output every week is certainly something very good now. When I first joined the Board it was very small—sometimes only £100, while now we have increased it up to occasionally £1,000 a week. I fancy that the cause of the increase here is the extension of the radius which the Postmaster-General has granted to the telephone companies. In the United States I find, on looking through a report, that there are no fewer than 128,000 telephones running, while in the United Kingdom there are only 12,000. Surely in the five years to come, while we are sole manufacturers of the instrument, the telephone must make a start—at all events, we must hope it will. We have at this moment a large order from the Postmaster-General. Mr. Preece, the electrician, has stated to me that he has never had a better instrument turned out of the factory than at this present moment. He is extremely satisfied with it. I may also say that we have independent testimony from Sydney, in Australia, where gentlemen are using the Consolidated telephone in preference to any other. The Canadian Government have ordered of us lately a small number of instruments, and with that order we received a letter saying that they are highly pleased with the transmitting power of our instrument. We look to that to get us some special orders in the future. Abroad there is not the slightest doubt that we could do a large business, but at a very small profit, and I think it would be unwise at present to press that business too much. We are doing a little on the Continent, and we have received offers to do business from Sweden, Italy, and Holland, but the profit is so small, that while we have got a fair amount of business here to occupy us I think it would be unwise to accept such orders. The matter, however, has our attention. We have entered into negotiations with a certain body of gentlemen to execute a large order for Canada. If we get that it will take a very considerable time to execute. Before I quit this subject I cannot help saying a word of praise for our general manager, Mr. Mason, to whom I assure you we are all very much indebted for the manner in which he has worked our business. With respect to the exchanges abroad, we give at the end of the report a statement of what we have done in the course of the year. I think that alone as a business should prove highly satisfactory. We have increased the subscribers to the exchanges by 914, with an increase in the annual income of £6,472. That has been done at a capital expenditure of about £22,000, roughly speaking. The manager in Austria, who is present at this meeting, having just arrived from Vienna, states that we have there no fewer than 870 subscribers, and that there are 284 persons waiting to join the exchange. I should like to point out that, according to Mr. Krause, when we have got 1,100 subscribers connected up and paying, the revenue to the Austrian Company will be £9,000 and the working expenses about £3,870, leaving in round figures a net profit on the business of £5,000. I think if we consider that all these exchanges abroad are gradually working up to a paying position, we have every reason to congratulate ourselves, because in due time there is no doubt that those businesses will be one and all returning us a large income. While on the subject of the Austrian Company I would mention that one of the Directors, Mr. Bateman, went out to Austria to examine and see what the property there was, and he has come back with a very high opinion indeed of that business. We have, through introductions which members of this Board have obtained, got into communication with the Minister of Commerce (Baron Gino) in Vienna, and we have greatly improved the status of the Company by doing so. As you are aware, at one time the relations between this Company and the Austrian Government were nearly being broken off and the concessions forfeited. At Lisbon and Oporto matters are progressing satisfactorily. The number of subscribers there has increased during the past year by 284, while the gross rental has increased by £1,559. There is only one other point I would allude to with respect to the Edison-Gower-Bell Company, and that is that they are remitting money home, and Mr. Danvers says he hopes to be able to send between £2,500 and £3,000 this year. I have had a letter this morning from the River Plate from Mr. Powers, who says that everything is going on very splendidly with them there. The exchange question is injuring us to some extent, because there is no possibility of sending back money from that part of the world with the rate 33 per cent. against you. At the present moment we are examining closely into all the details of expenditure, and I hope and trust that, with the continued increase of the manufacturing business at home and abroad, and the exchanges all working into paying concerns, the absolute success of the Consolidated Company will be secured in the future. I believe it will, and we shall do all that we can to keep this business in the sound position to which we have brought it. I will now propose "That the Directors' report and statement of accounts for the past year be received and adopted."

Mr. JOHN TAYLOR seconded the motion.

A short discussion followed, and, in reply to questions,

The CHAIRMAN said, with regard to the selling price of the telephones, that he had known as much as £20 to be given. He did not think it would be wise to say what the Canadian Government would give. With respect to the amalgamation of the two companies in the River Plate, the opposition company was willing to amalgamate, but they wanted such high terms. He believed that the Chairman of the opposition company would be in London next month, and no doubt Mr. Taylor would see him and try and get better terms. As to raising the rates in that country, to compensate them for the fall in the exchange, that would be a dangerous proceeding, in view of the opposition. As a matter of fact, he would like to do so, and he would also like to raise the rates in Austria. He thought this was a question which must be left with the Board.

A SHAREHOLDER asked if the £214,000 in shares of subsidiary companies possessed any value?

The CHAIRMAN said he thought the question was an awkward one to answer. They could only judge what value these shares were by knowing that the Companies were every day improving in their business, and getting nearer to paying dividends.

A SHAREHOLDER: Are you open to a bid for them?

The CHAIRMAN: Yes. He then put the motion, and it was carried unanimously.

The retiring Directors, Major FitzGerald, Messrs. J. Taylor and R. Van-Zeller, were re-elected, as were also the auditors, Mr. J. G. Griffiths (Messrs. Deloitte, Dever, Griffiths, and Co.) and Mr. A. E. Green.

Mr. A. H. Baker (a Director) said, with regard to the question which had been asked as to the value of the shares held by the Company in the subsidiary companies, that if the business of those companies went on increasing in the same ratio as heretofore, they would not only be worth something, but something very considerable. If the subsidiary companies progressed as they had been doing, they would not only pay the charges, and the interest on the preference shares, but there would be something for the ordinary shares, on which this Company had put no value.

Mr. GRIFFITHS (one of the auditors), in reply to a question, stated that a charge of £1,500 was made against the profits last year in respect of the goodwill and patent rights. As a matter of fact, the patents were dying out every day, as all patents did, and though the goodwill might be improved, the auditors thought that some provision should be made for the patents for some years to come.

The CHAIRMAN, in further reply, pointed out that the amount standing in the balance sheet against good will and patent rights was £87,000, against which they held £214,000 in shares of other companies. If these shares were worth £87,000 they did not need to write off very much more from the value of the patent rights.

A vote of thanks to the Chairman and Directors "for their able and honest management of the Company's affairs" was then proposed and seconded, and

Mr. MASON, in support of the vote, said he thought the shareholders ought to know that the Chairman was at the factory every morning from eight to nine o'clock, looking over the correspondence, and giving the best attention to the Company's business, besides giving them a large amount of time during the day.

The CHAIRMAN, in reply to the vote, which was unanimously agreed to, assured the shareholders that the Directors would do all in their power to make the Company a success, and he thought they would do so.

The proceedings then terminated.

The South of England Telephone Company.

The first ordinary general meeting of this Company was held on Thursday, the 28th instant, at the City Terminus Hotel, Cannon-street, Mr. Robinson Kendal in the chair.

The SECRETARY (Mr. Fred. L. Robinson) having read the notice calling the meeting,

The CHAIRMAN said that the meeting had been called in conformity with the Companies Acts. It was what was called the statutory meeting, and it had to be held within four months of their incorporation. Practically there was no business to be brought before the shareholders, but as they had assembled together perhaps it would be as well that he should give them a few facts and figures in regard to their own Company in particular, and also in regard to the present position of telephony in this country. The Parliamentary Committee which had so exhaustively discussed the question of overhead wires had reported very favourably as to telephony—in fact, so favourably that he believed telephonic companies had

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little or nothing to complain of in that respect. The local authorities and public bodies had hitherto placed serious obstacles in the way of telephonic enterprise, but after the exhaustive inquiry that had been carried on before the Parliamentary Committee he thought there was every reason to believe that those obstacles would be largely removed, and that in future they might look for a degree of tolerance, if not favour, from the public authorities throughout the country. The fetters and shackles with which telephonic enterprise had been bound since its introduction into this country by the Post Office authorities had now also largely disappeared, and practically telephone Companies had little or nothing to complain of compared with what they had twelve or eighteen months ago. As an instance of this, he might mention that he was in Cambridge the other day and had the honour and privilege of meeting the representatives of the two public bodies that governed that particular place, namely, the representatives of the Town Council and of the Improvement Commissioners, and after discussing the question of introducing the telephone into Cambridge, those bodies not only agreed to it, but warmly promised to give the Company every assistance in their power in introducing their system into the town. The same thing he might say had happened in regard to other places. At first, owing to the perversity of human nature, or to causes into which he need not now enter, whenever it was attempted to start a telephonic system in any town or city it was met with obstacles of one kind or another, and the local authorities almost uniformly cursed its introduction, but in the end it had been found in every case that what they began by cursing they ended by blessing. All the local authorities had been glad finally to adopt the telephone in connection with their fire brigade stations and other municipal institutions. Still, there was at this moment a vast degree of ignorance in regard to what the telephone really was. In a large town not many miles from London, where, a short time ago, they sent one of their local managers to open up a system, the head and chief local authority inquired whether their representative brought any testimonials showing what the telephone had done in other places or what it was supposed to do in connection with that town. The Company's representative said that he thought the telephone was known all over the world, but that local authority gave him to understand that they knew nothing about it. So much with regard to telephony in general. With regard to their own Company in particular he wished to give a few facts. As the shareholders all knew, they had a very large district, and that large district had, until their Company was formed, hardly been developed at all. The district worked by this Company comprised the counties of Northampton, Norfolk, Bedford, Cambridge, Huntingdon, Buckingham, Oxford, Berks., Suffolk, Sussex, and that portion of the counties of Kent, Essex, Surrey, and Hertford which was not included in the district of the United Telephone Company, which district comprised the county of Middlesex, and a radius of twelve miles from the General Post Office in London. The Company was only registered some three and a half months ago, and practically it was only six, or let him say seven, weeks since they had been actively at work in connection with the development of that district, and bringing their enterprise before the notice of the residents generally, and he ventured to think that during those six or seven weeks in which they had entered into their territory they had not allowed the grass to grow under their feet; but they had actively and zealously endeavoured to carry out the work committed to their charge. He saw no reason why their business should not be very larely developed, so that in fact the time might come when in every house of any consequence there should be means of communication by telephone with all the principal places in the neighbourhood. They had a tolerably large, successful, and improving exchange at Brighton. It had something like 200 members at the present time, and the number of subscribers to it was increasing daily, and he looked forward to the time when that exchange would be a very great success, and would, he thought, play a very important dividend-earning part in the affairs of the Company. They had exchanges also at Norwich and Ipswich. That day they opened one at Chatham and Rochester, which he thought promised to be one of the most successful exchanges in connection with their district. In five or six days they expected to open one at King's Lynn, and another at Hastings, while both at Reading and Northampton they had taken premises for an exchange. At Cambridge also they had secured suitable premises, and they hoped within eight or nine days to enter upon a very successful business in that town. They had been received very cordially by the Norwich municipal authorities and by the Improvement Commissioners, and he looked forward to the time when their system would extend over the whole town of Cambridge, where he believed they would have an opportunity of showing what could be done in the way of developing telephonic enterprise, as it might be shown in the internal arrangements of the different colleges and houses in the neighbourhood. Hitherto largely the telephone had been confined to the exchanges; but there was no reason why that should be so. There was, indeed, every reason, on the contrary, why the telephone system should be so developed that house and house, even dining room, bed room, and kitchen, should be connected just as completely as the exchanges now were. They had looked into the question of running different trunk lines, and they expected before long to make satisfactory arrangements for giving it a practical trial as soon as they had the requisite number of subscribers. They had made the necessary inquiries to see whether they could not run a trunk line between Chatham and London and other places, and he had no doubt they should be able to do it so profitably as to realise paying returns. Without taking into account any of the prospective business likely to accrue to them from the opening of the exchanges which he had named, their income from the orders they had on hand, executed and unexecuted, this month alone amounted to more than £750, which, he thought, considering that they had been practically in existence only for six or seven weeks, was very satisfactory indeed. There was no reason why this income should not increase month by month. If it did not do so he thought he might promise them on behalf of his colleagues, and he certainly spoke for himself, that it would not be through any fault of theirs. The telephone ought to progress and develop, and if it did not the fault would be the fault of the people on his side of table. They had made arrangements calculated to develop the business over that larger district. They had engaged a number of active, zealous, and experienced young men, whom they had sent at no great cost to their district, and they thought with the assistance of those young men, who would be watched and encouraged, they would be able to increase their business and produce a satisfactory result at the end of the year. They had no drones on their staff, nor any sinecure in their service, and when they took these facts into consideration, he thought the shareholders might rely on this, that, when they met to receive their first balance sheet, they would have no cause to regret having committed their interest to the care of the present Board, who, they would see, had endeavoured as far as in them lay to develop telephonic enterprise.

Mr. BEAVIS asked how many towns were connected with London by trunk lines.

The CHAIRMAN replied that at the present time they were only connected with Brighton, but they had it in contemplation to connect Reading, Chatham, and Rochester. They did not intend to commit themselves to any undertaking, unless they could get a guaranteed number of subscribers to make it a sure paying and successful operation. In further answer to the same gentleman the Chairman said that the Company had quite sufficient money for carrying on their business. They had £30,000, and he did not think they would require any more for a considerable period.

A vote of thanks having been accorded to Mr. Kendal for presiding, the proceedings terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. MAY 27.		BUSINESS DONE WEEK ENDING MAY 27. Highest.		Lowest.	
Anglo-American	27½,	28½	.....	26	.....	—
Do. Preferred	47½,	48½	.....	48½	.....	48½
Do. Deferred	7,	7½	.....	7½	.....	6½
Brazilian Submarine	10¾,	11	.....	10 15-16	.....	10¾
Cuba	10½,	11	.....	11	.....	10½
Do. Preference	17½,	18½	.....	17¾	.....	—
Direct Spanish	1½,	2	.....	—	.....	—
Do. Preference	10½,	11½	.....	—	.....	—
Direct United States Cable	8½,	9	.....	9	.....	8¾
Eastern Telegraph	11½,	11½	.....	11½	.....	11½
Do. 6 per Cent. Preference	13½,	14	.....	—	.....	—
Do. 5 per Cent. Debentures, 1839	105,	108	.....	—	.....	—
Eastern Extension	12½,	12½	.....	12½	.....	12½ x.d. &
German Union	9½,	9½	.....	—	.....	—[bonus
Globe Telegraph and Trust	6⅞,	7⅛	.....	7 1-16	.....	6 15-16
Do. Preference	12¾,	13	.....	12 15-16	.....	12¾
Great Northern	13½,	14	.....	13¾	.....	13¾
Indo-European	30½,	31½	.....	—	.....	— x.d.
Reuter's	7½,	8	.....	7⅞	.....	—
Submarine	175,	185	.....	—	.....	—
West India and Panama	¾,	1	.....	13-16	.....	—
Do. 1st Preference	7⅞,	8¼	.....	8	.....	7⅞
Western Brazilian	5⅝,	5¾	.....	5⅝	.....	5½
Western Union 7 per Cent. 1st Mortgage	117,	122	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	100,	103	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅝,	¾	.....	—	.....	—
Oriental	⅛,	¼	.....	—	.....	—
United Telephone	11½,	12	.....	12¼	.....	11⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1½,	2	.....	—	.....	—
Do. (fully paid)	3,	3½	.....	—	.....	—
Hammond Light (£3 15s. paid)	¼,	½	.....	—	.....	—
Swan	¼,	½	.....	—	.....	—
Maxim-Weston	¼,	½	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	35,	36	.....	35¼	.....	35¼
India Rubber, Gutta Percha, and Telegraph Works	21½,	22½	.....	22¼	.....	21¾

TRAFFIC RECEIPTS FOR APRIL, 1885.

COMPANIES.	April, 1885.		April, 1884.		Increase.		Decrease.	
Brazilian Submarine	—	....	—	....	—	....	—	
Cuba Submarine	3,700	....	3,410	....	299	....	—	
Direct Spanish Telegraph	1,510	....	1,811	....	—	....	301	
Direct United States	—	....	—	....	—	....	—	
Eastern Extension	41,233	....	37,044	....	4,189	....	—	
Eastern Telegraph	63,085	....	51,975	....	11,110	....	—	
Great Northern	24,800	....	—	....	—	....	—	
Submarine	—	....	—	....	—	....	—	
West Coast of America	4,215	....	—	....	—	....	—	
Western and Brazilian	—	....	—	....	—	....	—	

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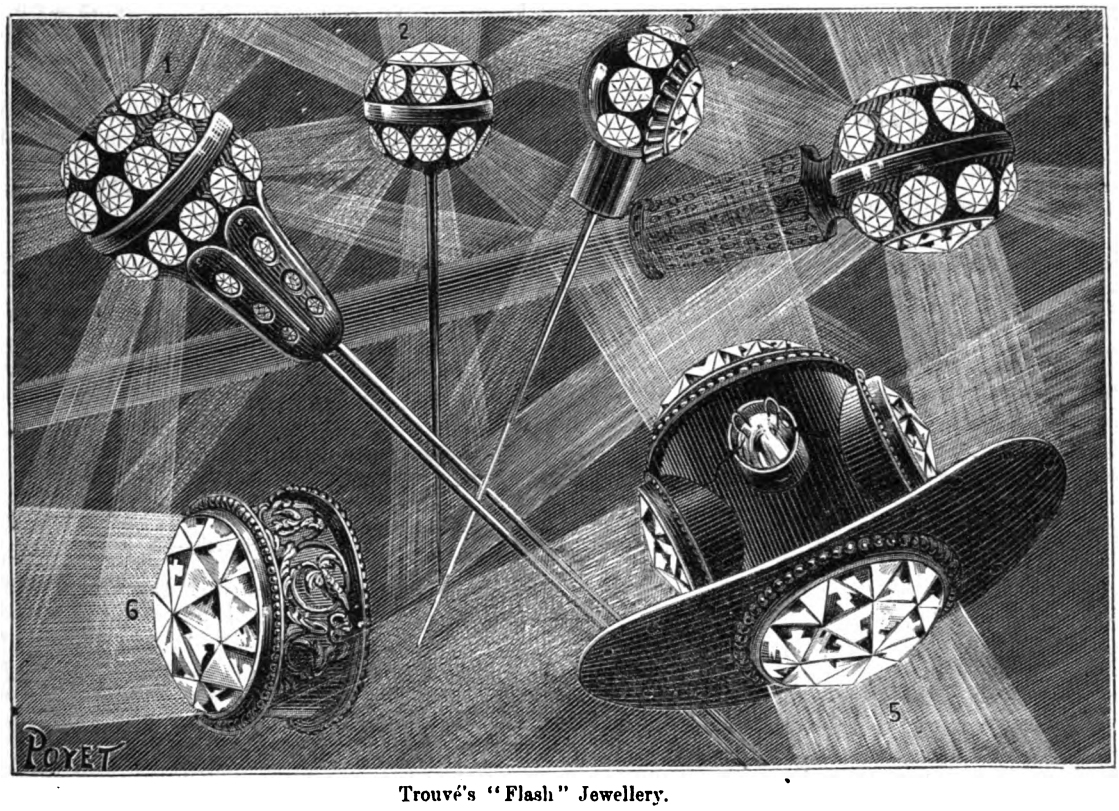
THE INTERNATIONAL INVENTIONS EXHIBITION.

The same remark with which we previously commenced applies still—progress is very slow. The chaos in the machine room is, however, gradually giving place to order, and the visitor is able to gain a somewhat better idea of what it will be like when completed than he was two weeks ago. It will easily be understood, however, that systematic arrangements for describing the exhibits are altogether impossible. Workmen here, workmen there, workmen everywhere, create a scene of confusion which prevents the tracing of circuits, or of careful investigation in any shape. One conspicuous weak point is in the lighting of the arcade devoted to Group XIII—the electrical exhibits. Naturally we look for the acme of electric lighting, and are met with nothing but oil lamps. However, it may be that by the time the goddess of the weather has decided to give us warm bright evenings the Exhibition will be practically perfect. We may take this opportunity of stating that we have arranged for a more scientific investigation into the merits and demerits of the dynamos and motors, independent altogether from the merely descriptive report of the exhibits. We hold that the interests of our readers will be best served by such a course. The illustrated descriptive matter may be looked upon as food for babes, the critical matter for the sustenance of those who have passed out of the weakling into the youthful or even maturer stages. While exhibitions follow so closely upon one another the casual investigator fails to see the progress made; to him the Siemens, Crompton, Brush, Gramme, or other machine is still the same. The change of weight in the field-magnet cores, the change in the winding of field-magnet or armature, the detailed alterations in brushes and other parts fail to rivet attention, because on the whole the "type" of construction remains the same. But the constructor knows that every change of screw or material has been made with a definite object, and that after trial the object for which the alteration was made has been partially or wholly attained, otherwise the old form would remain. It must not be expected that these minor alterations always or even frequently have for their object electrical improvements; they may, and many have, an objective in the simplification of the arrangement, or in improved construction. To those who desire to obtain a thorough knowledge of what has been done during the past six or seven years we suggest not only a careful investigation of the forms of to-day, but also a careful comparison of these with the forms that are now looked upon as obsolete. Our object, however, is description, not sermonising. Then, again, wending our way to Group XIII. in the East Arcade, let us commence by directing attention to the exhibit of M. Trouvé, one of those exhibits which can be looked upon as complete. So much has been said of M. Trouvé's work, and the greater portion of these exhibits have been so often described and illustrated, that our work is of the simplest. The study of economic science shows us that a large part of the human race has to be satisfied if it can obtain necessaries, while another part can revel in luxuries. Many of M. Trouvé's exhibits partake of the luxurious, in that they show how the electric light lends itself to artistic decoration. We do not know whether the flash jewellery so largely used for theatrical effects is to be classed as luxurious and decorative, but we do know that M. Trouvé has a large number of specimens of this kind of jewellery. Briefly, for the sake of the younger readers, we may say that M. Trouvé was, so far as practical purposes are concerned, the original investigator into the possibilities of a secondary battery. His investigations have led him to devise various forms of secondary batteries and incandescent lamps for mining and other purposes. The original form of Trouvé battery was simply opposed plates of lead rendered porous by continued charging and discharging, so as to obtain large surfaces for the storing up of electrical energy. During the period of charge one plate is chemically acted on to form peroxide of lead. If a plate so peroxidised is placed in a cell containing dilute sulphuric acid opposite to a plate of pure lead, and the two plates are joined by means of a wire like any other voltaic cell, a current passes through the wire, as long as any peroxide remains unreduced. In *The Electrician*, Vol. XIV., page 26, will be found various illustrations of portable lighting apparatus, consisting of Trouvé batteries and incandescent lamps intended primarily for mining purposes; while in the same volume, p. 128, are illustrations of other forms to be used for



Trouvé's "Flash" Jewellery.

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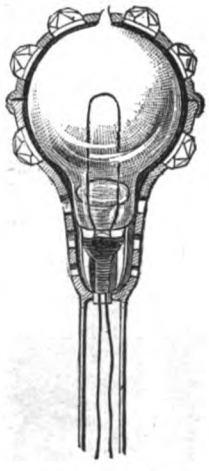
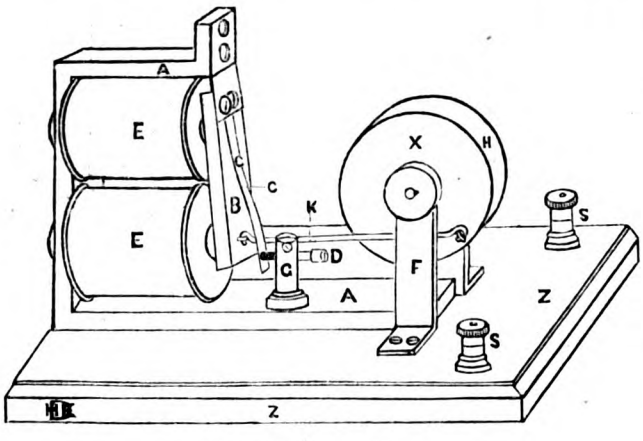
various purposes, such as investigating gas pipes in long tunnels, or in fact wherever a gas escape is suspected; for lighting gas lamps; for carriage lamps, &c. Passing once more from the grave to the gay, we repeat our illustration of "flash" jewellery, to give some idea of what may be seen in M. Trouvé's exhibit. The smaller illustration shows how the light is arranged, a small lamp of one or two candle-power inside surrounded by glass facets for the purpose of directing the rays. We have no doubt that this exhibit will prove the most interesting in the arcade, so far as ladies are concerned,



Trouvé's Electric Pin.

although many may prefer the style of decorations shown by Mr. Swan.

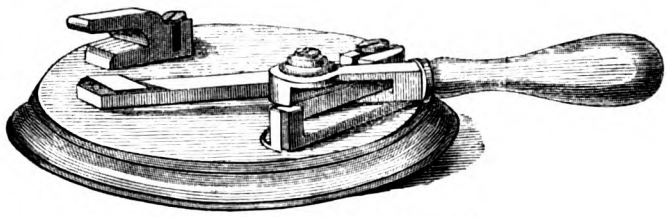
A new patent electric clutch motor is exhibited by Messrs. Bayley and Son, of Poole, Dorset. This is arranged to be entirely self-starting at full power, in any position, and to be self-regulating. The chief faults of small electro-motors hitherto have been that they would not start themselves, and that however effectual they might be when running at a high speed, when that speed was reduced not only was the power reduced but the current required was increased. The subject of our illustration, however, is said to possess neither of these faults; it is self-starting in any position, it regulates its length of stroke according to the work to be done, its highest speed is only about 200 or 300 revolutions per minute, and its "pull"



Bayley's Clutch Motor.

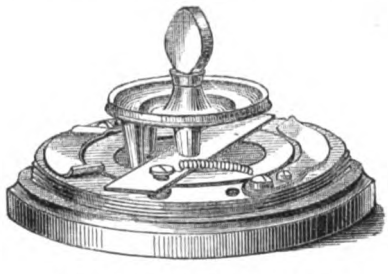
is very great. For example, a pulley was fixed to the spindle of a Griscom motor, weighing 2½lb. On connecting it with a battery of six good sized bichromate cells a weight of 3oz. was drawn slowly up; on connecting the same pulley and battery to one of these clutch motors, having four times the resistance and weighing 2lb., a weight of 30oz., was lifted. The motor consists of an electro-magnet, E, in front of whose poles is an armature, B. This armature is provided with a contact spring, C, and contact breaker, G, so that as the current passes the magnet may be alternately magnetised and demagnetised. A second magnet, H, is provided, mounted upon an axis, which axis may be in any position, and this magnet, with its axis, is free to revolve. In front of the poles of this second magnet there is a loose disc armature, X. This loose armature is attached by a rod, K, to the vibrating armature B of the electro magnet E. The current passes entirely through both magnets, when immediately the armature B is attracted to the poles of E, and the loose disc X is also drawn by reason of its attachment to B; but as at the same time the electro-magnet H is excited, it clutches or holds the disc X, and is carried round a slight distance with the disc. The spring C then breaking contact, both magnets become demagnetised, and the armature B falls back, the disc returning to its former position. Contact is again made, and the same routine of operation proceeds. Thus the axis, with its magnet and pulley, revolves by reason of a rapid succession of reciprocating motions, which are converted into a continuous and uniform rotary motion, whether the load is on or off. A is an iron frame to which the magnet E is secured, F the brass bearings of the axis and clutch magnets, S S the terminals for attaching the battery wires, and Z Z the polished mahogany base board. For working as an electric bell a cam is placed upon the axis, which at every revolution acts on the spring arm of the hammer, and causes the bell to sound with great power. By providing suitable gearing the rotary motion can readily be transmitted. As to the power required, it is said to be very small, the comparatively large power of the motor being due to the short direct attraction of the armature by the electro-magnet and to the minimum of friction loss which has been arrived at.

Messrs. J. H. Holmes and Co. (Stand 1,375) show a variety of electrical fittings. Of switches, cut-outs, &c., we may say their number is legion, and certainly much study of them would be wearisome. The pioneer in cut-outs, Mr. Killing-



Holmes' Switch—Single Contact.

worth Hedges, is represented elsewhere, but almost every electric light engineer is getting out his own design of switch and cut-out. The exhibit of Messrs. Holmes and Co. needs little description. The type of switch will be seen from the illustrations given. Of course the designer claims that his switches prevent the formation of a destructive arc when the



Holmes' Switch—Duplex Contact.

current is broken, have the surfaces kept clean, and good contact ensured by their coming together with a rubbing motion. In these switches the contact piece is made independent of the handle, so that on breaking contact it may fly back suddenly under the influence of a spring only, and out of the control of the operator. The contact, therefore, is broken so quickly that the spark is not of sufficient duration to cause any damage. The spring is arranged to keep the movable contact piece in the "off" position, but on turning the handle to complete the circuit

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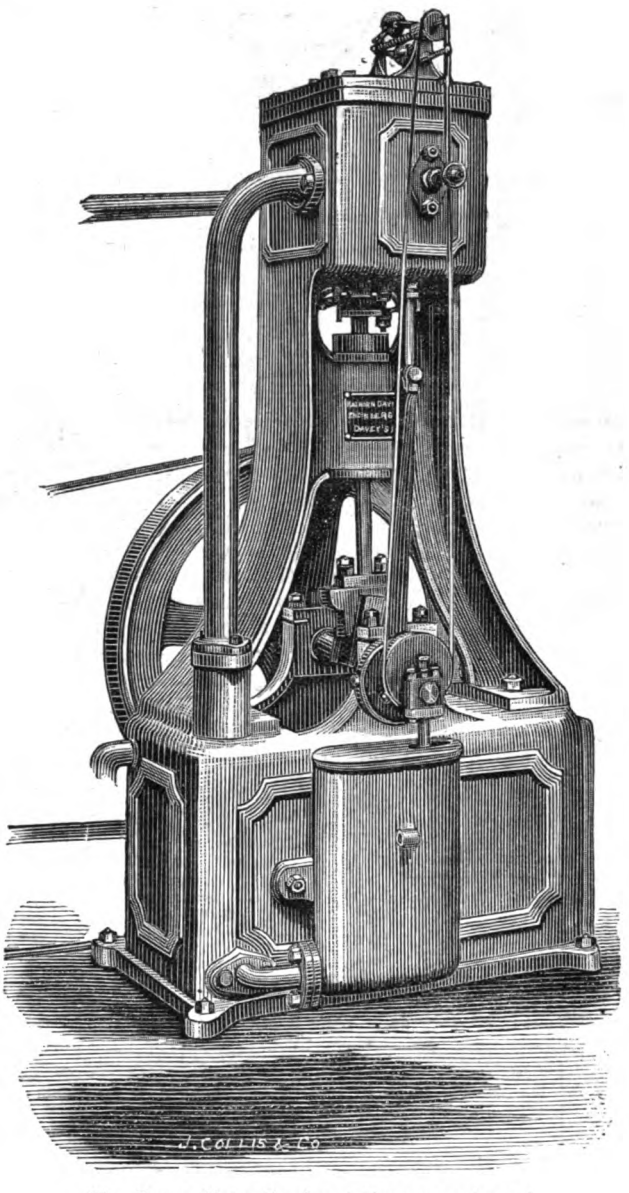
the contact piece is moved in opposition to the pressure of the spring and is kept in the "on" position by being forced between the fixed jaws and held there by friction. The handle may traverse about 30° without moving the contact piece, always pushing the bar before it when making or breaking contact. On turning the handle to break circuit its first action is to release the contact bar from its frictional hold, allowing it to dart away suddenly under the influence of the spring, thus breaking the circuit so quickly that a dangerous arc cannot be formed. These switches are made in a variety of patterns on either wood or slate bases, and with terminals either on the face of the block, or below, so that in the latter case switch-boards may be arranged to look as neat in appearance as possible.

We may be permitted to digress from Group XIII. to Group II. in the South Gallery. Passing from the machine room to the East Arcade, we have often watched at work the little model machine shown by Messrs. Ernest Scott and Co. This machine is intended to separate iron from other substances. From the following description it will be seen that the separation can only be effected when the other substances are not attracted by magnets. To show the working, the mixed material is fed into a hopper marked "Iron, brass, and refuse," from which it falls upon the nearest of the two endless belts, and is taken under a rotating disc carrying electro-magnets. This disc is carried upon a spindle, the upper portion of which revolves against a commutator, so arranged that contact is made as each section of magnets comes over the nearest belt, and broken as it arrives over the other one. It therefore follows that the electro-magnets pick up iron from one belt, and when over the other drop it, having, by the cessation of the current, ceased to be magnetic. By this means the iron is collected in one hopper, and the material from which it has been extracted in another. Many previous attempts, say the inventors, have been made to utilise magnetism for the separation of iron from other substances with which it may be mixed, but they have all failed to accomplish any great amount of useful work. When permanent magnets have been used, as in the well-known "magnetting machines," the amount of material treated in a day is very small, as the iron has to be removed by mechanical means, and the magnets are brought into direct contact with the substance treated, which accounts for the comparative slowness of the process, and also for the fact that the compounds with which the metal is mixed cling to the particles of iron, and are thus taken out at the same time; while, in the electro-magnetic machines previously patented and suggested, no really efficient or adequate means have been provided for removing the iron from the magnets.

In our issue of November 1, 1884, we described and fully illustrated the exhibits of the Pilsen Company at the Healtheries. The company has an exhibit of a similar character at the Inventions, so that having so recently referred to the apparatus we shall content ourselves with a shorter reference. The dynamo-electric machines are of the Schuckert type. The exhibits are arranged to show clearly the nature of these modifications introduced by the company, and the advantages to which they have led. Four machines are used to maintain the arc lamps, three being in actual use, one kept as a reserve. The core of the armature is of soft hoop iron wound up tightly in volute form. The layers of iron are separated one from another by strips of calico or longcloth wound in with the iron; a sufficient number of turns is given to form the broad flat ring characteristic of the Schuckert type, and the sections of wire are then wound upon it. The central boss carries a number of radiating arms terminating in a kind of fork, into which the hoop-iron is wound directly. This method of mounting the armature allows the latter to be built up of large diameter. The sections of wire on this ring in some of the company's dynamos are separated one from another at the periphery by soft iron shoes or wedges insulated from the rest of the iron in the core. It is claimed for these separate pieces that they increase the efficiency of the machine. At the Exhibition two of the machines maintain 14 arc lamps each through about 400 yards of wire leads, at a speed of 775 revolutions a minute. Each of the remaining two, having more wire on the armature, maintains 14 arc lamps through about 400 yards of leads, at a speed of 614 revolutions. The current meter, of which there is one on each circuit, has the form of an ordinary flat-coil galvanometer, the directive action of whose coils is intensified by the introduction of soft-iron cores. Between the poles of this electro-magnet rotates a soft iron armature against the tension of a spiral spring. This armature carries an indicator needle, which moves over a graduated dial. The shape given to the poles of the electro-magnets produces equal deflections for equal increments of current. The readings are constant, and the armature is sensitive to extremely small variations of current.



The Davey Motor (for description see next page).

The West Gallery, in which are the principal exhibits of machinery in motion, is lighted by Pilsen arc lamps. These are of the common type known as P^1, the characteristic features of which are the biconical solenoid core and tandem coils. Near the machines are exhibited other types known as P^3, having two conical cores and parallel coils; P^5, having tandem coils placed horizontally; and P^2, which is the latest development. In this lamp there is but one spool, on which are wound both the main and the shunt coils, within which moves a single tapered core. It is claimed for this lamp that it possesses the steadiness of feed distinctive of the other

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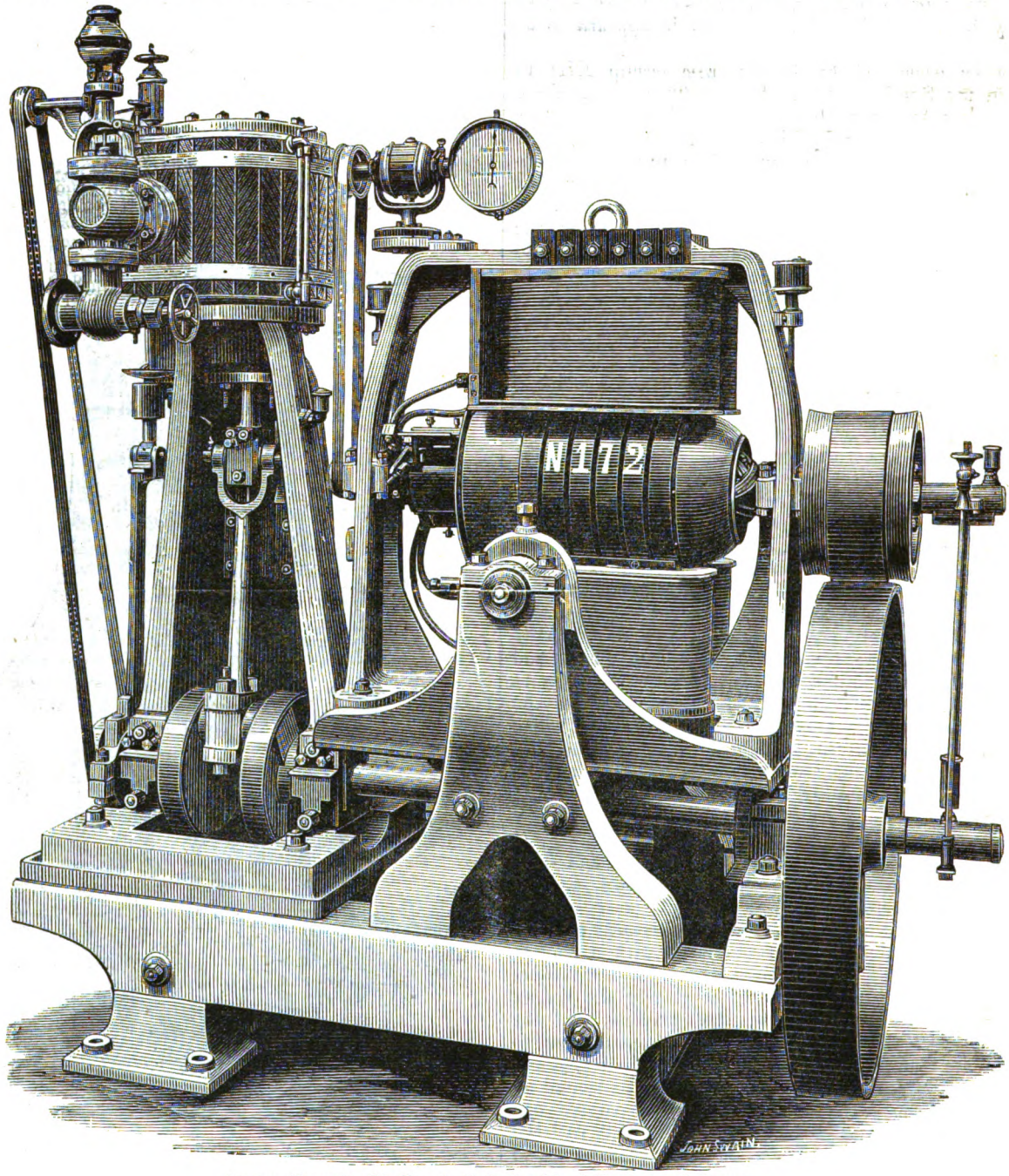
types of Pilsen lamps, while its moving parts are so few that derangement is, with reasonable care, hardly possible.

In a preceding notice we mentioned that two of the Davey motors, as described in *The Electrician*, March 14th, this year were at work in the engine shed. By the side of the magnificent engines of Messrs. Davey, Paxman, and Co., these little motors appear as pigmies, yet they will be found to have their uses. The illustration on preceding page shows the engine at the Inventories which differs but slightly from that given in our previous description. The engine is double-acting, and supplied with steam at or about the atmospheric pressure subsequently condensed. The vacuum obtained The vacuum obtained in the condenser is 25 to 26in., and an experiment was made to show the degree of vacuum required to overcome the friction of the engine and resistance of the air-pump, with the result that, with a condenser vacuum only 5in. of mercury lower than the boiler pressure, the engine ran at its normal speed. As, under ordinary working conditions, the difference between the boiler and condenser pressures is about 25in. of mercury, there is an available margin of 20in. of mercury, or say 10lb. per square inch above that required to overcome the friction of the engine. This shows an efficiency of 80 per cent, not a bad result; and, working at atmospheric pressure, the Davey motor is no more liable to burst than a tea-kettle, while, as the boiler is self-feeding and the fire can be made up to last for a long time, the least possible attention is required.

Messrs. Browett, Lindley, and Co., late Deacon and Parker, show a vertical compound engine, and an engine and dynamo combined, which we now illustrate. The engine has a 6in. cylinder and 8in. stroke. The dynamo is mounted on a swinging frame. The heaviest end of this is next the fly-wheel of the engine, and is supported by the pulley of the dynamo resting on the fly-wheel. The pulley consists of discs of paper compressed between two iron discs, and is caused to revolve at 800 revolutions per minute, while the engine makes about 150. In order to increase the adhesion there are two light rods, as shown, which unite two brass bearings, one on the dynamo spindle and the other on the crank shaft, and by turning two hand nuts screwed on the rods, the pulley can be forced down on the wheel and thus more adhesion obtained. This arrangement seems to run very well; but its value will be better understood at the close of the Exhibition, by which time it will have undergone a pretty severe test.



Messrs. Browett, Lindley & Co.'s Combined Engine and Dynamo.

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NOTES.

NEW AMERICAN COMPANY.—The North Western Electric Company has been incorporated at St. Paul, Minn.

ANOTHER ELECTRICAL EXHIBITION. — An International Electrical Exhibition is to be held in Milan in 1887.

MANUFACTURE OF ACCUMULATORS.—M. Epstein, of Leipzig, is about to transfer his manufacturing business to Berlin.

ELECTRIC LIGHTING OF A TOWN.—It is announced that the town of Saint-Jean-de-Maurienne (Savoie) is about to be electrically lighted.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 29th May amounted to £2,971.

THE TELEPHONE IN PARIS.—The telephone did good service in Paris the other day, on the occasion of an extensive fire in the Rue Michel-le-Comte.

ELECTRIC CLOCKS.—More than 700 electric clocks have already been installed in different parts of New York, and the demand for them is increasing rapidly.

THE EARTHQUAKE AT CASHMERE.—A despatch from the British Resident in Cashmere states that no Europeans were killed during the recent earthquake shocks.

NEW ELECTRICAL METER. — A new meter has been patented in Spain by D. Felipe Saldaña. Our contemporary, *La Gaceta Industrial*, is enthusiastic in its praise.

OBITUARY.—The death is announced at Berne on the 13th ultimo of M. Albert du Faure de St. Martial, Secrétaire du Bureau International des Administrations Telegraphiques.

THE DAFT MOTORS.—The Daft Electric Light Company are building some motors for testing the merits of their invention in a practical manner on some of the American railroads.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of May, 1885, were £1,345, against £1,552 in the corresponding period of last year.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 31st May are £3,813, as compared with £3,245 in the corresponding period of 1884.

THE ELECTRIC LIGHT FOR A CASINO.—The Casino at Aix-les-Bains (Savoie) is about to receive an installation of 20 Jablochkoff lamps, 14 regulators of a new kind, and about 60 Woodhouse and Rawson incandescent lamps.

THE EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of May amounted to £50,016, and to £41,708 in the corresponding period of 1884; increase, £8,308.

THE ELECTRIC LIGHT IN BARCELONA.—The cavalry barracks situated at Barceloneta, a suburb of Barcelona, is about to receive an installation of powerful arc lights. The Sociedad Espanola de Electricidad have charge of the work.

CIVILISING THE AMEER.—Complete apparatus for lighting the Ameer's palace by electricity has been despatched from Bombay to Cabul. The electric light took his Highness's fancy at Rawul Pindi, and he resolved to introduce it at home.

NOTICE OF INTERRUPTION.—The Eastern Telegraph Company notify the interruption of their duplicate Aden-Bombay cables. Until they are repaired telegrams for India, China, &c., should be sent through the Indo-European Telegraph Company.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 29th May, 1885, were £2,346, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

ELECTRICAL FITTINGS FOR THE ADMIRALTY.—We understand that the tender of Messrs. Goolden and Trotter, of 2, Victoria-mansions, Westminster, has been accepted for over 11,000 electrical fittings, of which a considerable quantity have already been delivered.

THE GLAESENER SECONDARY BATTERY.—We have to acknowledge the receipt of a cell and some specimens of electrodes, &c., from Glaesener Freres, of Chatillon (Luxembourg, Belge). We propose to thoroughly test this cell before entering into any discussion as to its merits or demerits.

STRUCK BY LIGHTNING.—A telegram from Calcutta states that a terrific storm raged at Hyderabad on Thursday last. The mess room of the 14th Hussars was struck by lightning while the officers were at mess, and two of them, Lieutenants Seymour and Bentley-Innes, were killed instantaneously.

THE EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of May, 1885, amounted to £61,327, and to £51,537 in the corresponding period of 1884. The exceptionally large receipts were caused by the Afghan frontier dispute, hostilities in the Soudan, and settlement of the war between France and China.

THE CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this Company during the month of May was 4,474, estimated to produce £3,700, against 3,339 messages, producing £2,973 in the corresponding month of last year. The traffic receipts for the month of February, estimated at £2,700, realised £2,730.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—An extraordinary meeting of this society will be held at the Institution of Civil Engineers, 25, Great George-street, Westminster, on Thursday, 13th June, at eight p.m., when a paper will be read "On the Calculation of Mains for the Distribution of Electricity," by W. H. Snell, associate.

THE "MAGNETA."—Mr. Commissioner Rothery held an inquiry on Wednesday last at the Sessions House, Westminster, into the loss of the "Magneta," which left London on March 8 with fifty-four hands on board, and which since the 10th of that month has not been heard of. The accounts of the pilots who were in charge of the vessel from Glasgow to London and London to Portland are that her behaviour was very satisfactory.

A THERMIC MOTOR.—For the past few months the Triple Thermic Motor Company has had under construction in Lowell, Mass., an engine proposed to be devoted to the use of the Middlesex Electric Light Company of Lowell. The engine was started at the works in Jackson-street on 6th May, and has given excellent results. It is said that all the dynamos of the Middlesex Electric Light Company will be transferred to the building at an early date.

ON THE MEASUREMENT OF MAGNETIC FORCES BY HYDROSTATIC PRESSURE.—Prof. G. Quincke adopts the formula

$$p = \mathfrak{A}_1 H_1^2 / 8\pi$$

where H_1 is the intensity of the magnetic field, and $\mathfrak{A}_1$ a "dimagnetisation constant" analogous to the dielectric constant in the analogous formula for the pressure in the electric field. Observations have been made on many magnetic liquids to ascertain the numerical values of this constant.

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THE POST OFFICE TELEGRAPHS.—According to a contemporary the increase of telegraphic business has been amazing. In 1871 the number of telegrams in the provinces was 5,300,000, and in London 2,900,000; in Scotland about 1,000,000, and in Ireland 606,000. But in 1883-84 the provinces sent 15,000,000, London 12,700,000, Scotland 3,300,000, and Ireland 2,000,000, making a total of 32,000,000, as against the 9,000,000 of 1871. The number was still increasing at the rate of about 2½ per cent. per year.

THE NATIONAL TELEPHONE COMPANY.—The list of subscribers in the Scottish North-Central District for the past month shows that this company is making satisfactory progress. The first telephone was not introduced into Dundee until 1879, and there are now in operation 915 telephones and 628 miles of wire in the district. The lines are operated upon Mann's circuit line system, which is said to possess in point of convenience many advantages over the systems adopted by other telephone companies.

WIRES COMMITTEE IN FRANCE.—The following gentlemen have been nominated members of the special commission appointed to consider the question of the proper and safe conveyance of high tension currents of electricity in France for electric lighting and other purposes:—MM. Baïhaut, député; Krebs, capitaine adjudant-major au régiment des sapeurs-pompiers; Fribourg, directeur du personnel, chargé de la direction du service central au ministère des postes et télégraphes; Brunot, chef de cabinet du ministre des postes et télégraphes.

THE TELEGRAPH IN THE FAR EAST.—With regard to the proposed telegraph between Hong Kong and Singapore Sir George Bowen, at a meeting of the Hong Kong Legislature, announced that the Eastern Extension Telegraph Company would require a guarantee of £20,000 a year for twenty years before undertaking to lay a direct cable. There is, therefore, no prospect at present of the scheme being carried out, especially as both the Legislatures of Hong Kong and Singapore agree that the present condition of their revenues does not allow them to offer any substantial aid to the project.

UNFORTUNATE.—The telephone is an admirable institution, more especially in America, but the too frequent use of the instrument sometimes leads to awkward mistakes. An old lady who happened to be deaf went into a linendrapers the other day and adjusted her ear-trumpet preparatory to commencing negotiations. Unfortunately for himself and his employer, an absent-minded shopman sent a stentorian "Hello" with such force against the old lady's tympanum that she flounced out of the shop without giving the science-stricken server of ribbons time to recover himself.

THE OBSERVATION OF EARTH MOVEMENTS.—Our contemporary, the *Science Monthly*, contains a very interesting account of some observations of earth-movements in Italy. For manifesting the noises and rumblings of the earth's crust a microphone was buried at a depth of five or six yards, in a retired and quiet situation. Small rods of metal were found preferable to carbon. A copper needle was balanced on a pivot, with its extremity resting on a bit of platinum. When a resonator was adapted to the receiver, the noise became strong enough to be heard in an adjacent room. Electrical apparatus was also used for registering the upheaval jerks and undulations of the earth.

LONG-DISTANCE TELEPHONING IN THE WEST INDIES.—Our contemporary *The Colonies and India* says:—By a simple connection of the telegraph wire to the telephone instrument in the News Room at Port of Spain, it was found that communication with San Fernando, a distance of 45 miles by wire, could be carried on with as much ease and precision as between any two places in the city. Remarking upon this achievement, the *Gazette* says:—"The day may not be far off when telephone subscribers will be able to converse between both towns, and to the police service such an acquisition would prove an immense boon. Several gentlemen conversed with Mr. Hodges, the telephone manager, at the other end of the line.

THE TELEPHONE IN THE WEST INDIES.—In 1882 the Tropical American Telephone Company started two exchanges in the West Indies, one at Barbadoes, and later one at Trinidad. The former was sold to local capitalists, who organised the Barbadoes Telephone Company. After reaching 140 subscribers at Trinidad the company encountered competition, a rival system, using M'Donough telephones, being started. The company reduced its rates, registered its English patents on the Bell and Blake instruments, and the opposition ceased. Trinidad merchants have now purchased the company's plant and property and are developing the business. There are now 200 sets of instruments at Barbadoes and 250 sets at Trinidad.

UNDERGROUND ELECTRICAL CONDUITS.—According to our contemporary the *Scientific American*, the Electric Underground Conduit Company have recently exhibited a new system of conduits in which each wire passes through a separate paper tube ¼in. in diameter. This tubing is surrounded by double layers of silvered paper to prevent interference from induction and supported by perforated partitions in wooden boxes. The surrounding space is filled with an insulating asphaltum compound. Each wire terminates at the stations in a separate binding screw, thus forming an independent connection throughout the entire system. This construction presents a decided advantage in case of accident, or where several companies use the same conduit.

THE FUNERAL OF VICTOR HUGO.—A contemporary says:—"In order to ensure the completion of the colossal Cenotaph, and of the fitting up of the Arc de Triomphe by Sunday morning, the men are now (Friday) working all night by the electric light, which has been temporarily installed. During the whole of last night the progress of the work was watched by crowds of people. In the blaze of the electric light the effect of the immense wooden structure, already partly covered with its sable draperies, against the massive proportions of the Arc de Triomphe was very remarkable; and the strangeness of the scene was increased by the ordinary street lamps all round the place being covered with crape and decorated with sheaves of bannerets."

THE ELECTRIC LIGHT IN MADRID.—The installation at the Teatro Real consists of 250 Siemens and Halske incandescent lamps of 25 candle-power each, 400 accumulators, and six Gramme dynamos, type A. The cost of the installation is said to be as follows:—

Steam motor of 14 horse-power	£290	12	6
Six Gramme dynamos (1 spare)	279	0	0
Shafting, &c.	27	2	4
400 accumulators	620	0	0
250 lamps	72	5	2
Cables	193	15	0
Cost of labour, &c.	193	15	0
Sundries	77	10	0
Total	1,754	0	0

The daily cost of the light as compared with gas is, taking it altogether, slightly in favour of the new illuminant.

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THE BELLE SAUVAGE PRESS.—From a small and beautifully illustrated pamphlet descriptive of the exhibits of Messrs. Cassell and Co., at the Inventions Exhibition we extract the following account of the electrotyping process as carried out by them :—"The type formes and woodcuts are delivered from the composing room to the moulding room, where wax impressions of each page are taken. These are placed in huge troughs, and subjected to electric action by means of a power-driven dynamo machine, similar to those used for producing the electric light. By this agency a coating of copper is deposited upon the mould, and a fac-simile of the page of type or woodcut is produced. This is 'backed up,' turned, planed, and otherwise finished in another room; then, after being examined, it is transferred to the imposing room, where all the plates are mounted upon metal blocks ready for the printer."

ELECTRIC LIGHT PATENTS.—Suits were begun recently in the United States Circuit Court by the Edison Electric Light Company against several companies which manufacture incandescent electric lamps and against the users of lamps made by these companies. The alleged infringers, against whom suits were begun, are the United States Electric Lighting Company, the United States Illuminating Company, the Consolidated Electric Light Company, and the Swan Incandescent Electric Light Company. The Remington Electric Light Company and the Schuyler Electric Light Company are also said to be among the companies against which actions are to be begun. The Edison Company asserts that its patents cover the incandescent lamp, the methods of manufacturing the lamp and lamp-sockets, fixtures for carrying lamps and sockets, construction of dynamos, &c. The amount of invested capital that will be affected by these suits is estimated at £3,000,000.

"DAS TELEPHON."—The following lucid and expressive little poem appears in a recent issue of our American contemporary, the *Electrical World*:—

Viele Wörter gibt es schon
Auf gut Deutsch fuer "Telephon":
Fernhinsprecher, Weithersänger,
Surrschnur, Säusler, Schallempfänger,
Plapperfaden, Wortaustauscher,
Sprechdraht, Klangstrick, Weithinlauscher,
Ohrverläng'rer, Antwortbringer,
Hausspion, Luftwellenklinger,
Weitschwatz, Kilometerzunge,
Stubenhorcher, Meilenlunge,
Sprechwerkzeug, Besuchersparer,
Tonrohr, muendlicher Verfahrer,
Doppelstahlblechzungenreger,
Klangverbreiter, Blitzwortträger,
Sprechpostschalter, Musikleiter,
Schallmaschine und so weiter.

A CLOCK ELECTRICALLY LIGHTED.—At the General Post Office, Melbourne, Victoria, the upper portion of the clock tower will be taken down, and it will then be raised till its total height reaches 188ft.; the present illuminated dials, which are too small to be of any practical use, will be dispensed with, and four new skeleton dials, each about 13½ft. diameter, will be provided, the centre of the dials being about 132ft. from the ground. A new feature will be introduced in connection with these dials; they will be made of cast iron, and will have hemispherical recesses so spaced as to mark the hours in place of the usual numerals; these will be nickel-plated inside so as to reflect the sunlight and form bright points in the daytime, and in these cups incandescent electric lights will be placed, while similar lights of smaller size will be arranged in a close row along each of the hands. It is anticipated that this arrangement will make it possible at night to tell the time by this clock at a great distance.

SUNDRY INSTALLATIONS ON THE CONTINENT.—At Dresden the Lesigke Restaurant has 30 Bernstein incandescent lamps, and the Theatre Royal 220 Edisons. At Munster 1,000 lamps light the clothing establishment of M. Hartmann. The stations, the workshops, the theatres, have all adopted the same means of illumination. There are 19 sugar manufactories possessing in all 3,300 incandescent and 42 arc lamps. The most important is that of Frellsteds with 600 lamps and 12 regulators. Four clothing establishments at Brunn have 700 Edison lamps. Kiel also possesses several installations, and the little town of Triberg is about to be similarly favoured. Amongst the installations which have lately been put down in Berlin we may mention that at the Hotel Central, carried out by Messrs. Siemens and Halske. This comprises a 40 horse-power steam engine, driving nine dynamos, each of which furnishes the current for five or six arc lamps, 37 regulators distributed through the hotel and gardens, and a number of incandescent lamps in the offices and private apartments.

THE ELECTRIC LIGHTING TESTS.—Some further details of the tests conducted at Philadelphia by the Franklin Institute, which have recently come to hand, show that as a result of 600 hours' continuous lighting, that of the 20 lamps submitted by the United States Company 12 have gone out; the Stanley Company have lost 16 out of their 20; the Woodhouse and Rawson Company have lost 9 out of their 10; and the Edison Company 1 out of their 20. All have lost some candle-power, some more than others, but no accurate statement could be had as to the efficiency—*i.e.*, the current necessary to send through each lamp. It was found that the Weston (U.S. Co.'s) lights required 3·6 watts per candle, the Edison 4·4, the Stanley 4, and the Woodhouse and Rawson 3·8. As to the dynamo test, which will begin in about two weeks, great care is exercised in the preparations. Only six dynamos are now in the building for testing, three of the Edison and three of the Weston pattern, but more are expected. The tests will not be finished before the middle of June.

THE LANCASHIRE AND CHESHIRE TELEPHONE EXCHANGE COMPANY.—From the list of subscribers for May in Manchester, Manchester sub-district, North Lancashire, and Liverpool sub-district, we note that this company have already joined up the undermentioned places by trunk wires, and that they purpose extending the list as rapidly as circumstances permit:—Accrington, Ashton-under-Lyne, Blackburn, Blackpool, Bolton, Burnley, Bury, Darwen, Heywood, Liverpool (including Bootle, Garston, Gateacre, Old Swan, Waterloo, and Wavertree), Manchester, Middleton, Oldham (including Hollinwood, Royton, and Shaw), Preston, Radcliffe, Rochdale, Runcorn, St. Helens, Stalybridge, Stockport, Warrington, Widnes, and Wigan. In the public call stations any one may converse by telephone, not only with subscribers to the company's exchanges, but also with anybody who, by previous appointment between the parties concerned, has gone to some other call station to receive a message. This feature will, no doubt, prove a great convenience to those who are not subscribers to the company's exchange system.

THE "MOLECULAR" TELEPHONE.—In the so-called molecular telephone of Messrs. Waite and Bartlett the receiver consists of a magnet bent into a semi-circular shape, with a re-entering end, to which is secured a soft iron core. To the side of the case there is secured an iron spring, which bears upon the diaphragm, and can be regulated by a screw. The

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diaphragm is made of wood, cork, cardboard, or other non-magnetic material. Thus the varying currents over the line cause vibration in the spring, which vibration is in turn communicated to the diaphragm. The transmitter employed by the inventors is a modification of the Hughes microphone. Mounted on a sheet of cork are six rods of carbon with reduced ends, the inner one of which fits loosely into holes in a central carbon button. Their outer ends are also supported by smaller buttons, connected up in two series of three in parallel. In the latest form of this transmitter the buttons are clasped by brass springs which encircle them, permitting of easy adjustment, and removable in case of breakage or repair. The articulation of this telephone is said to be very distinct, and inductive effects are considerably reduced in intensity.

NICKEL.—In the *Centralblatt fur Electrotechnicker*, Dr. Böttcher lately called attention to the valuable chemical properties of nickel, as well as its resistance to oxidation—even in damp air—and likewise to acids. When once dissolved it is only with great difficulty separated from its combinations. Regarding its electro-chemical properties, it is asserted that it does not precipitate copper from solutions of blue vitriol, and when joined with copper in these solutions gives no current, while the combination heat of copper with sulphuric acid is only 29,500 calories. Even with platinum nickel gives no current in sulphuric or hydrochloric acid. For the definition of the electro-chemical equivalent of nickel in combinations with sulphuric acid, nickel sulphate was electrolysed between the anode of lead and the cathode of nickel, when there were formed on the one side free sulphuric acid and superoxide of lead, and on the other metallic nickel. The electromotive force of this secondary element was one volt, and the caloric equivalent of the nickel 21,300. The resistance of sulphate of nickel in the electrolysis is considerable. For the separation of nickel from SO_4 an electromotive power of 2·32 volts is required. From this the tension of the current, in nickelling with sulphate of nickel and using a nickel anode, is 1·32 volt.

RESISTANCE OF CARBONS EMPLOYED IN ELECTRIC LIGHTHOUSES.—According to the *Proceedings* of the Institution of Civil Engineers, the Carré carbons employed in the French lighthouses are 0·016 metre in diameter, as used for the ordinary lights, and 0·024 metre for the "double" lights used when there are fogs. The resistance at 15° centigrade is, as nearly as may be estimated from a large number of bridge measurements, 70 ohms per square millimetre of section and per metre length, but the differences from this average amount to as much as 30 per cent. Mr. F. Lucas has made experiments to ascertain how these carbons vary in resistance with the quantity of electric current. The results led to the empirical formula

$$y = y_0 \left(1 - \frac{C}{25 \text{ amperes} + 1{\cdot}2\,C}\right),$$

y_0 being the resistance at 15° centigrade, and the quantity of current C varying from 50 to 142 amperes, when the coefficient of y_0 diminished from one-third to one-fourth. Further measurements as to the variation of temperature led to the formula

$$T - 15^\circ = \frac{C}{0{\cdot}112 \text{ ampere} + 0{\cdot}0004\,C};$$

and $y = y_0 \dfrac{1 + 0{\cdot}0005\ (T - 15)}{1 + 0{\cdot}0005\ (T - 15)}$, which may be applied for temperatures between 400° centigrade and 900° centigrade. Putting $\theta = T - 15^\circ$, the number of calories disengaged per second is

$$K = \frac{y\,C^2}{4{,}154} = \frac{0{\cdot}0747\theta^2 + 0{\cdot}000024\theta^3}{104{,}000 + 434\,\theta - 0{\cdot}397\theta^2 + 0{\cdot}000083\theta^3}.$$

The cooling surface for a cylinder of 0·016 metre diameter, and 0·400 metre length, being approximately 20,000 square millimetres, $\dfrac{K}{20{,}000}$ gives the fraction of a calorie disengaged per square millimetre of surface for each value of θ.

APPLICATION OF PHOTOGRAPHY TO ELECTRICAL MEASUREMENTS.—Messrs. Trowbridge and Hayes have devised and communicated to Silliman's *American Journal* a method by which the action of a voltaic cell can be studied at leisure, the apparatus not requiring continuous observation. A beam of light from a gas flame passes through a vertical slit placed in front of the flame, and is reflected from the concave mirror of a tangent galvanometer, of few turns of wire, through a horizontal slit, in a dark box, in which a sheet of sensitive paper is placed. By means of this arrangement of a vertical and a horizontal slit, a small point of light is obtained. A stationary concave mirror is placed near the needle of the tangent galvanometer, so that the same beam of light may be reflected by both this mirror and the one attached to the galvanometer-needle. The spot of light given by the stationary mirror serves to mark the zero point of the needle when no current is passing through the galvanometer. The photographic paper is placed in a slide which is lowered uniformly by the unwinding of a string from a little cylinder placed either upon the hour-hand or the minute-hand of a cheap eight-day clock. When the electrical current from the voltaic combination, which is being used, passes through the galvanometer, its changes in strength for different times are indicated by the relations of two lines drawn upon sensitive paper. The line drawn by the light from the stationary mirror is a straight one, and serves for the abscissa of times; while the perpendicular distances from the curve drawn by the mirror attached to the needle of the galvanometer to this axis of times give the ordinates of the curve drawn by the latter. Rapid printing paper was used, and an ordinary gas flame gave a sufficiently strong spot of light to produce an actinic effect. Knowing the distance of the galvanometer from the sensitive paper, the strength of the current may be calculated by measuring the distance between the two lines at any instant, and proceeding as with an ordinary galvanometer and scale. From a comparison of two figures the electromotive force may be determined by Ohm's law, if the distance between the lines is measured at the instant the current is made. Then knowing the electromotive force, current, and external resistance, the internal resistance can readily be found. It is evident that the same photographic method can be employed to study the swing of the needle of a short coil-galvanometer, which indicates the gradual heating of a thermopile. In this way the conduction of heat along a bar could be studied.

ELECTRICITY IN THE NAVY.—The following is an abstract of a lecture delivered by Lieutenant A. W. Chisholm-Batten, R.N., of the torpedo ship "Vernon," at the Royal United Service Institute, on the 29th ultimo, on "Electricity as Applied to Naval Purposes." He pointed out that there was no sharply defined line between the application of electricity for general and for war purposes. It was a great power in skilled hands, and could be used with safety and certainty even by slightly trained men if only enough care and thought were taken in designing the appliances so as to make their use easy and abuse difficult. Having given a brief description of how electricity for naval purposes is generated, he drew attention to its great use for illuminating purposes on board ship, the only drawback being that a failure resulted in total darkness, and great care was necessary to prevent the current affecting the compasses and chronometers. For the search light for discovering torpedo boats approaching, and for bom-

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barding forts the arc light was needed, and by it a boat could be discovered at a great distance. Much use had been made of this light at Alexandria and Suakim. For signalling it had been used for years, and had been distinctly visible at 31 miles from the ship. For internal communications electricity was very valuable in ships, the applications for this purpose being already very numerous and on the increase continually. Telephones are used from ships, when moored, to the shore, and this communication has been found very useful on board the "Vernon;" and, in co-operation with the glow lamp, it was found very valuable for diving, and had already been the means of saving life. Electricity had been already successfully applied to the propulsion of launches, one called the "Australia," with a speed of seven or eight knots, having been built for £180. The application of electricity to war purposes was first in firing guns singly or by broadsides; offering great advantages in the latter case of all the guns being fired exactly at the same moment. An observer, who has not been incommoded by smoke, is therefore able to time the discharge when it will be most effective. In a heavy sea the guns can be fired at the moment the ship is upright. Electricity has proved most valuable for firing, propelling, and discharging torpedoes, a name strangely enough derived from the electric fish. For firing star torpedoes electricity is now exclusively used, and also for firing towing torpedoes, and it was now being applied to firing, propelling, and steering the fish torpedo of the type known as Sims', which is considered to have long range, handiness with the helm, a heavy charge, security from an enemy's fire, power of passing floating obstructions, not being easily seen or stopped by an enemy, its motive power always ready and not dangerous, constant speed to the end of its run, and its charge is exploded at a proper depth, to a greater degree than those of Ericssen, Lay, Howell, and Whitehead. It is made in two sizes, the larger carrying two miles of copper wire and 400lb. of dynamite. The Paulson torpedo is steered by electricity, while all torpedoes started from below the deck are discharged by electrical signals. Submarine mines, which might be defined as stationary torpedoes, could be fired either by contact or by electricity at will. In explaining the latter, which is called double observation firing or plane table firing, he said it had the disadvantage of not being applicable at night or in a fog. To obviate this, electro-contact mines were used, in which a ship blew herself up by running against one of a number of mines. The torpedo detector consists of a sinker or heavy case and a box carried in the boat from which the cable hangs. The sinker is dragged slowly along the bottom, and when it comes in contact with a mass of magnetic metal, such as a torpedo case, a humming noise is set up in the box, indicating the fact to those in the boat. In every case the various appliances were shown in actual use by the lecturer, who had skilled assistance from the "Vernon."

A SCHOOL OF TELEGRAPHY.—From an article in the *Daily News* we extract the following:—"The institution styled at full length the School of Submarine Telegraphy and Electrical Engineering, situated at the junction of Princes-street with Hanover-square, now established for some seventeen years, affords the visitor ample and interesting evidence of the giant advance into everyday life made by electricity. On entering No. 12, Princes-street, we find some forty or fifty youths engaged with various practical operations in which electricity is employed. A gas engine of eight horse-power is running to drive the dynamo machines of various construction, and the scholars are busy in testing work, in making drawings of apparatus, and in sending and recording messages by submarine telegraphy, exemplified by the mirror galvanometer and by the siphon recorder. Practical work is going on, not only in the rooms fitted with every kind of the most elaborate apparatus, but in the basement, where students are occupied in charging a formidable array of the so-called secondary batteries in which the storage of electricity is made. Others are busy in testing batteries with condensers, and at the extremity of the main floor a dark chamber is occupied by Bunsen's photometer, somewhat modified in accordance with a suggestion of Sir William Thomson, LL.D., F.R.S., who has reported most favourably on the method of instruction pursued in the school, and takes a keen interest in it like Prof. Fleeming Jenkin and Mr. Preece, who have sent their sons there, to go through the regular course of theoretical and practical instruction. This course, which extends over a minimum term of twelve months, with additional time for the same fee if the pupil be slow and painstaking rather than apt, includes the entire science and practice of applied electricity as known generally in the three great sub-divisions of telegraphy, especially as applied to submarine cables, the installation and management of electric lighting on various systems, and the construction and organisation of telephones and telephone exchanges. The practical working of various systems of telegraphy, telephony, and illumination is taught, from the management of the gas engine and various makes of dynamos to the construction of incandescent lamps, the delicate operations necessary for detecting the whereabouts of a flaw in a submarine cable, and also the use of the photometer in determining the candle-power of electric lamps and the best method of employing accumulators to advantage. This practical department is mainly got through in the morning, the afternoon being devoted to the theoretical course embodied in lectures delivered by the managers and other competent instructors on mathematics, chemistry, and general physics in relation to electricity, the general doctrine of energy, gas and other motors, electro-statics, and electro-dynamics, the relation between magnetism and electricity, including the theory of and mode of constructing dynamo and magneto-electric machines, the theory of electric lighting by means of arc and incandescent lamps, including the principles of their construction, the theory and details of construction of the various forms of secondary batteries or accumulators, the theory of the telephone and microphone, the testing and localising faults in electric circuits and engineering formulæ." We are glad to be able to add to this by no means exaggerated account of an admirable institution an extract from a letter written by Sir Wm. Thomson, dated the 16th ultimo. He says:—"Nearly eleven years ago I expressed a favourable opinion regarding the efficiency, for the teaching of submarine telegraphy, of an institution which has continued doing good work ever since that time, and which now has a well-deserved reputation as the School of Electrical Engineering and Submarine Telegraphy, of Princes-street, Hanover-square. A few days ago I had the pleasure of again visiting it, and was much pleased to find large extensions from its original province of submarine telegraphy into all branches of electrical engineering, while still retaining all its efficiency in the practical teaching of telegraphy. It is now well equipped with apparatus and appliances for the teaching of electric measurement, photometry, the management of dynamos, the practice of electric lighting, and other commercial applications of electricity. With these valuable adjuncts for illustration and practical exercise, the fundamental scientific principles are methodically taught in a series of systematic daily lectures and examinations under the superintendence of Mr. Tiddy and Mr. Carpenter, and their able assistants, in a manner which seems to me exceedingly well adapted to benefit their pupils."

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ALTERNATING CURRENTS.

BY THOMAS H. BLAKESLEY, M.A., M. INST. C.E.

(Continued from page 23.)

Correction.—The Electrician, May 22nd, 1885, p. 23, column 1, line 14 :—In formula, after the words "which may be written," strike out the 2 in the denominator.

Line 26, insert *l* between the words "as" and "increases."

By the help of the formulæ which have been given, especially of those connected with the case in which the cable is put to earth, we can deal with some important questions in long distance telephony. The falling off in current corresponds to the failing in intensity of tone produced. The fact that this falling away in current depends upon the period, being greater as the period is smaller, will explain the alteration in character of a composite tone, those components which have a higher pitch suffering more decay than lower notes.

The subjoined table will facilitate the calculations of such effects :—

θ	$\frac{\cosh\theta+\cos\theta}{2}$	$\frac{\cosh\theta-\cos\theta}{2}$	$\cosh\theta$	$\cos\theta$
0·0	1·	·0	1·	1·
·01	1·	·0000500	1·0000500	·9999500
·02	1·	·0002000	1·0002000	·9998000
·03	1·	·0004500	1·0004500	·9995500
·04	1·0000001	·0008000	1·0008000	·9992001
·05	1·0000003	·0012500	1·0012503	·9987503
·06	1·0000005	·0018000	1·0018005	·9982005
·07	1·0000010	·0024500	1·0024510	·9975510
·08	1·0000017	·0032000	1·0032017	·9968017
·09	1·0000027	·0040500	1·0040527	·9959527
·10	1·0000042	·0050000	1·0050042	·9950042
·2	1·0000667	·0200001	1·0200668	·9800666
·3	1·0003375	·0450010	1·0453385	·9553365
·4	1·0010667	·0800060	1·0810724	·9210607
·5	1·0026043	·1250217	1·1276260	·8775826
·6	1·0054004	·1800648	1·1854652	·8253356
·7	1·0100056	·2451634	1·2551690	·7648422
·8	1·0170708	·3203641	1·3374349	·6967067
·9	1·0273482	·4057382	1·4330864	·6216100
1·00	1·0416915	·5013892	1·5430807	·5403023
1·1	1·0610573	·6074612	1·6685185	·4535961
1·2	1·0865066	·7241489	1·8106555	·3623577
1·3	1·1192066	·8517078	1·9709144	·2674988
1·4	1·1604328	·9904656	2·1508984	·1699672
1·5	1·2115614	1·1408362	2·3513978	·0707252
1·6	1·2741325	1·3033320	2·5774645	– ·0291995
1·7	1·3497354	1·4785800	2·8283154	– ·1288446
1·8	1·4401355	1·6673376	3·1074731	– ·2272021
1·9	1·5472209	1·8705105	3·4177314	– ·3232896
2·0	1·6730244	2·0891713	3·7621957	– ·4161469
2·1	1·8197334	2·3245796	4·1443130	– ·5048462
2·2	1·9897036	2·5782048	4·5679084	– ·5885012
2·3	2·1854716	2·8517475	5·0372191	– ·6662759

As an example of the use of the table, suppose the following problem :—

A cable possessing ·2 microfarad of capacity per kilometre, and a resistance of 2½ ohms per kilometre, is 40 kilometres long. What will be the relation of the current at the sending end to that at the receiving end for a tone whose period is $\frac{1}{500}$ of a second?

Adopting quadrant units, we find that since the cable has ·2 microfarad per kilometre, it has ·002 farad in one quadrant; therefore, C = ·002.

Since the cable possesses 2·5 ohms in one kilometre, it has 25,000 ohms in one quadrant; hence $\rho = 25{,}000$. The period is $\frac{1}{500}$ of a second; hence $2T = \frac{1}{500}$.

Since the length of the cable is 40 kilometres, l = ·004 of a quadrant; hence a, which is equal to $\sqrt{\rho\frac{C\pi}{2T}}$, has for value $\sqrt{25{,}000\times\cdot002\times\pi\times500}$; or $a = 280{\cdot}25$. Hence $2al = 2{\cdot}24$, which is the number corresponding to θ in the table.

Looking, therefore, horizontally between the lines headed 2·2 and 2·3, and under the column headed $\frac{\cosh\theta+\cos\theta}{2}$, we shall be able to deduce the number 2·06 by interpolation. This number is the relation of the square of the current at the sending place to the square of the current at the receiving place. The relation of the currents themselves will be the square root of this number, *i.e.*, about $\frac{144}{100}$.

Now, suppose we investigate what takes place with the note one octave lower than that already considered. In this case, $2T = \frac{1}{250}$, and a will be found to be 198·17, and $2al$ will be 1·59, the number corresponding to θ in the table.

The value of $\frac{\cosh\theta+\cos\theta}{2}$, for this value of θ, will be found from the table to be 1·265, and the square root of this is 1·125, so that for this note the telephone current is reduced in the ratio of 112 : 100. For higher notes, the falling off of the currents would increase very rapidly. At the octave above the first note considered, the current would be reduced more than in the ratio 300 : 100.

Now the notes considered come well within the range of human tones in speech. The fundamental tones of the voice are, moreover, richly accompanied by harmonies of a high order, by means of which, however unconsciously, we interpret under ordinary circumstances the sounds received upon the ear. All such harmonies would suffer very materially in the course of the transmission.

Thus, at the end of a cable of any considerable length and capacity the various tones of the voice would be received in a state of degradation depending upon their pitch. If this were not the case, if all the tones were reduced in strength in the same proportion, a relay might be employed to restore the various currents to their original intensity, or to one in which the ear would readily appreciate the meaning of the tone. But the ear has not the synthetic power of reconstructing a composite tone from the wreck of variously degraded components. In this consideration reside the limits of telephony. Until this consideration is more clearly understood than it seems to be at present, people will fail to understand the exquisite nonsense to which they are often now content to listen about the possibilities of being able to listen to the minutest modulations of voice of a transoceanic prima donna, and so on. It would be more to the purpose to endeavour to keep $2al$ small. Lord Rayleigh at Montreal looked to alternating currents "to educate so-called practical electricians whose ideas do not easily rise above ohms and volts." It is to be hoped that this anticipation will be realised, for unfortunately the imputation conveyed is too well deserved. In a book specially published by the Institution of Civil Engineers in 1884, upon the practical Applications of Electricity, there is a paper by Sir Frederick Bramwell on Telephones, in which the following sentence occurs :—

"You all know that if an iron plate . . . . be caused to approach towards or recede from a permanent magnet, that magnet being surrounded by a coil of insulated wire, there will be set up in the coil of wire electric currents, which will vary in direction according as to whether the plate is approaching the magnet or is receding from it."

In this sentence it is clearly assumed that the induction, whose phase does accompany the phase of the plate's motion, is also accompanied in phase by the current. The mistake is made that induction is of the nature of current, instead of electromotive force. The induction produced by the plate's motion is the impressed electromotive force, but there may arise electromotive forces of self-induction, and those due to capacity in the conductor, which would cause the current to have a phase differing from that of the plate's motion, and to suffer at the same time a diminution in strength, both effects depending upon the pitch of the note producing the vibrations of the plate.

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These are the effects which will ultimately give a limit to telephony. But further on in the same paper, we read "As many persons have asked, what is the limit of possibility? I would say that I should think it depends practically on the excellence of the insulation and the avoidance of induced currents."

Now, if by induced currents is meant currents produced by accidental induction from outside, it seems likely that such currents would not so materially affect the interpretation of the sound as would the degradation of the currents which it is desired should be transmitted. For the ear, which is ultimately the organ to interpret, is every day practising the art of discriminating between two or more contemporaneous and superimposed sounds. The ear is, in fact, an excellent analyser, but for the process of recomposition necessary before a degraded composite tone can be truly interpreted something more than power of analysis is necessary, and this the ordinary ear does not possess.

To return to investigation. The dynamometer reading at distance x from the generator in a cable put to earth at the distant end is

$$\epsilon^2 \frac{C\pi}{2T\rho} e^{-2ax} e^{-2a(l-x)} \left\{ e^{2a(l-x)} + e^{-2a(l-x)} + 2\cos 2a(l-x) \right\}$$

$$= \epsilon^2 \frac{C\pi}{T\rho} e^{-2al} \left\{ \cosh 2a(l-x) + \cos 2a(l-x) \right\}$$

$$= \epsilon^2 \frac{C\pi}{T\rho} e^{-2al} \left\{ \cosh 2ad + \cos 2ad \right\}; \text{ where } d \text{ is the distance from the remote end, and for a cable whose end is insulated, it is}$$

$$\epsilon^2 \frac{C\pi}{T\rho} e^{-2al} \left\{ \cosh 2ad - \cos 2ad \right\}.$$

The relation is $\dfrac{\cosh 2ad + \cos 2ad}{\cosh 2ad - \cos 2ad}$.

Now, a reference to the second and third columns of the table shows that the numerator of this fraction does not always exceed the denominator. At certain values of $2ad$, those in fact for which $\cos 2ad$ is equal to zero, which recur periodically, the numerator is equal to the denominator, and the excess changes sides. The first of such cases occurs between $\theta = 1{\cdot}5$ and $\theta = 1{\cdot}6$, *i.e.*, when $\theta = \frac{\pi}{2} = 1{\cdot}57$.

If, therefore, the length and structure of the cable and the period of alternation are such that $2al$ is greater than $1{\cdot}57$, there will actually be regions of the cable at which, as far as the intensity of the currents received is concerned, it would be better if the circuit were an open one than that the distant end should be put to earth; and as we increase the length of the cable this state of things alternates with the other at fixed distances from the far end in the following way:—

Deduce a distance λ such that $2a\lambda = \frac{\pi}{2}$;

whence $$\lambda = \frac{\pi}{4a} = \frac{1}{4}\sqrt{\frac{2T\pi}{\rho C}},$$

and set off from the far end distances corresponding to λ, 3λ, 5λ, &c.

Then in the region within λ of the far end the current will be greater when the end is put to earth. In the region, length 2λ, between 3λ and λ from the far end, the current will be greater when the end is insulated. In the next region of length 2λ, it is best to put the far end to earth. And so on alternately for every length of 2λ. At the points where these alternating regions join, there will be a constant current whether the end is put to earth or not.

This distance 2λ is one quarter of the wave length of the undulation in the infinite conductor (*vide* p. 510, Vol. XIV.).

(To be continued.)

NOTE ON THE REGULATION OF DYNAMOS.

An interesting peculiarity exhibited by self-regulating dynamos wound for constant difference of potential is that such machines regulate equally well at any speed within fairly wide limits. This peculiarity must be common to all compound machines so wound, but the degree to which it is manifested depends on the construction of the machines. In this article an attempt will be made to explain the cause of this phenomenon.

The simplest expression for the E.M.F. of a series dynamo is given by the equation

$$E = N(a + bC) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where E is the E.M.F., C the current, a a constant depending on the permanent magnetism, and b a constant depending on the winding of the field magnets, &c. This equation means that when the circuit is open there will be a certain E.M.F. exhibited by the machine which is due only to residual or permanent magnetism, and that when the circuit is closed through a resistance and a current allowed to flow there is added an E.M.F. due to the increased magnetism of the fields which is proportional to the current. The equation is not true for all currents flowing through the machine, it is only approximately true for some little distance along the characteristic curve; nevertheless it is quite sufficient for our purpose, and it is the fundamental equation which serves as a basis for the construction of compound self-regulating machines. In such machines we have a a constant depending on the magnetism furnished by the shunt coil, and b a constant depending on the winding of the series coil, &c. Calling R the external resistance, r the combined resistance of the armature and series coil, C the current through the lamps, and c the current through the shunt coil, we have

$$CR + r(C + c) = N\{a + b(C + c)\} \quad . \quad . \quad . \quad (2)$$

Remembering that b depends on the series winding of the magnets, and that the E.M.F. added by the series coil when the circuit is closed is proportional to the current, we can, if we make $Nb = r$, write

$$CR = Na. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

If this condition is fulfilled in the winding of the series coil the machine will be constructed so that at the speed N the series coil will add to the circuit an E.M.F. equal to Cr, and this done the difference of potential at the terminals C R is a constant for all currents, and depends only on the strength of field supplied by the shunt coil and on the speed of the machine. Since the shunt coil is connected to the terminals of the machine, where the difference of potential is by hypothesis to be constant, the amount of magnetism furnished by the shunt is constant.

It is unnecessary to take up space by drawing the saturation curve of a dynamo. Such a curve is obtained by separately exciting the machine, running it at a constant speed, and observing simultaneously the E.M.F. and the current flowing round the magnets. The former being plotted as ordinates and the latter as abscissæ, we get a curve representing the relation between the strength of field and the excitation given to the magnets. Readers will remember that from the origin of the curve for some little distance the line is approximately straight, but that very soon it bends over towards the horizontal. Now, all expressions for the winding of compound machines, so far as the author knows, are based on the conception—a false one, as we shall see—that there is so much iron in the magnet cores that this curve for the whole of the excitation supplied by both shunt and series coils remains approximately a straight line. This means, of course, that the strength of field produced in the magnets is throughout proportional to the exciting current, and as a corollary it has been assumed that the machine will only regulate at one speed. This speed has been termed the critical speed for the combined resistance of the armature and series coil, a term which has no very distinct meaning in the case of compound machines, as the speed can generally be varied more than 50 per cent. without detriment to the regulating

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power of the machine. It must also be remembered that in a machine having cores of excessive softness, were the strength of field proportional to the exciting current the machine on open circuit would be necessarily running at a speed which would be critical for the resistance of the shunt coil, plus the armature, plus the series coil, and the E.M.F. would be in consequence indeterminate. When thus running on open circuit, both shunt and series coils furnish a certain excitation to the magnets, and on the assumption that each ampere-turn furnished by the series coil has the same absolute value as each ampere turn furnished by the shunt coil, as far as strengthening the field is concerned, we have for the proportion of series to shunt wire the expression

$$\frac{\text{Turns of series wire}}{\text{Turns of shunt wire}} = \frac{\text{Resist. of arm.} + \text{R of series coil}}{\text{Resistance of shunt coil}}$$

The series coil when the machine is running on open circuit furnishes the E.M.F. necessary to send the exciting current through the armature and series coil, and the shunt coil the E.M.F. necessary to send the current through itself. When the circuit is closed the ampere turns added by the series coil should be just sufficient to raise the E.M.F. by an amount equal to $C\,r$, where C is the current through the lamps. But the expression given above, based as it is on the assumption that the saturation curve is a straight line right from its origin to the extreme limit of excitation, always gives the turns of series wire much too low.

The effect mentioned at the beginning of this article, namely, the regulating of the machine at several different speeds, is entirely due to the bending over of the characteristic, and in all cases the curvature has become very decided while yet the machine is running on open circuit. The E.M.F. added by the series coil for any particular speed depends on the value of b. If we draw a saturation curve to show the relation between the current exciting the magnets and the E.M.F. for any particular speed, we shall find that b is continually altering its value. For instance, in a series machine designed to give a current of 20 amperes the E.M.F. added to the machine, due to the current being increased from five amperes to 10 amperes, is much greater than the E.M.F. added by an increase of current from 10 to 15 amperes. This is simply because b gets less and less as the magnets get more saturated. It will be seen that in the compound machine the value of b for a given number of series turns depends on the amount to which the magnets are saturated by the shunt and series coils before the current is allowed to flow through the lamps. If the magnets are only partially saturated the value of b is high, if fairly well saturated the value of b is low. In any case its value is proportional to the tan of the angle which the curve makes with the horizontal at that point, which represents the excitement given to the magnets by the shunt and series coils before the circuit through the lamps is completed. If this is true, obviously each ampere-turn furnished by the series wire has a very different value to that furnished by the shunt; and in illustration of this fact we have only to cut out the shunt wire of a machine and run it at the speed at which it runs as a compound machine, when we shall find that from the series wire only we shall get something like a difference of potential of 60 volts at the terminals with the full current on in a machine which, at the same speed, regulates at 100 volts with the shunt coil in. This shows that without the shunt coil in action the value of the series wire is very much greater, for the coil which merely furnishes an E.M.F. sufficient to send the current through the armature and itself when the magnets are excited by the shunt is capable of producing an E.M.F. of over 60 volts when there in no initial excitation. This experiment also shows us that for a given number of convolutions of series wire and a given resistance of armature and series coil a certain relation must exist between the speed of the machine and the degree to which the magnets are excited by the shunt coil—in other words, since the value of b depends on a, and since the condition of regulation is that $N\,b = r$, it is only when the degree of saturation produced by the shunt is such as to make $N\,b = r$ that the machine will regulate.

The equation $E = N\,(a + b\,C)$ has been given as the fundamental expression for the E.M.F. of a compound dynamo. It has been shown, however, that the value of b depends on a, and that it is continually changing as a is increased or diminished. But the value of b is assumed in the construction of compound machines to remain constant for the distance along the saturation curve which represents the difference in the number of the ampere-turns exciting the magnets when the lamp circuit is open and the number of ampere-turns when the full current is flowing through the machine. That it is not quite constant even for this distance is shown by the slight curvature in the characteristic of the compound machine, but the error is not great and forms no practical barrier to the use of these machines.

From the foregoing remarks we can clearly understand how the machine regulates at several different speeds. The magnetism furnished by the shunt coil depends on the speed of the machine; as the speed is increased a is increased, the magnets being saturated by the shunt coil to a greater degree than formerly. But we have seen that in moving the point corresponding to a further up the curve the value of b is diminished. The E.M.F. added by the series coil at the new speed is still, however, equal to $C\,r$, because in consequence of N having increased and b diminished the product $N\,b$ has still its former value. In consequence of the saturation effect the machine will regulate at all speeds where the increase in N compensates for the diminished value of b, or for all speeds where $N\,b = r$.

W. B. Esson.

CORRESPONDENCE.

ELECTRICAL NOMENCLATURE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I think English electricians should feel much indebted to Prof. Jamieson for bringing forward the subject of uniform electrical notation and nomenclature. We were fast drifting into a position in which this work would have been done for us by others, and then, when too late to discuss the matter effectively, a few of the more prominent among us would have been invited abroad to accept and adopt the new notation, cut and dried, amidst a profusion of hospitalities. This is very pleasant from a social point of view, but hardly consistent with the position which this nation has hitherto held in connection with the development of electricity.

I am glad that you recognise the fact that "the men of theory must of necessity to some extent give way to the men of practice." The former are well able to take care of themselves, but I doubt whether it is possible to make one system suitable for both—their wants are so entirely different that I think it would be almost wiser to recognise the fact and act upon it. The electrical industry is fast becoming a common handicraft. A large generation of working men has risen who have no time or even desire to study the theory of their trade, and everything should be made as easy as possible for them. They have only just sufficient education to interpret the very simplest equations, and for their use and benefit I would advocate that our new electrical measures should be ordinarily represented *by their first letters only.* I would even go further and advise that in their case the time-honoured $C = \frac{E}{R}$ should be abolished, and that $A = \frac{V}{O}$ should be substituted. I know how revolutionary this will appear; but there are two parties to be considered. To a practical algebraist there is no appreciable effort involved in mentally converting his amperes, volts, and ohms into C E and R, and in shaping the familiar equation into the form which he requires, and in afterwards re-converting his results back again into the then equivalents A V and O. This has to be done every hour, and is very easy to most people when sitting at the table; but how unsuited is it to the wants of the working engineer, with his hands greasy with oil, chalking his figures on a board amidst the whirr of dynamos. For him there should be no conversion of symbols

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As a specimen of what is more suited to his case, I venture to subjoin a set of workman's formulæ, in which initial letters only are used, and by which he can obtain the values of A V O, &c., from their various combinations. Here he finds a formula suited to every case he can meet, and he writes down his measures and obtains his results in familiar signs with scarcely an effort of thought. This simple nomenclature is equally suitable for other electrical formulæ, and is in fact being adopted by many electrical writers. Whether it will be accepted by more advanced mathematicians is another question, as they have to deal with other subjects besides electricity. I am quite aware that such a table as that given below is to them an abomination. What is the use, they ask, of so many figures? The whole of the formulæ can be instantly produced when required by any one ordinarily familiar with Ohm's law; and they turn away from such a mass of symbols with disgust. But these considerations do not apply to the working mechanic, and he ought not to be called upon to change the form of an equation or to turn C E R into A V and O amid the whirl of his machinery. I am inclined to think, upon the whole, therefore, that two systems of notation must come into use, the one for working men, the other for mathematicians, though they would not differ materially from each other.

I trust these views will meet with due consideration by the committee who are to be appointed to consider the question.—Yours, &c., LATIMER CLARK.

6, Westminster-chambers, May 29, 1885.

ELECTRIC LIGHTING NOTES.

$$\left(C = \frac{E}{R}, \text{ or } A = \frac{V}{O}\right).$$

Amperes A $= \frac{V}{O} = \frac{W}{V} = \sqrt{\frac{W}{O}} = V \times M = \frac{C}{t \text{ seconds}}$ $= 10^{-1}$ C.-G.-S. units.

Volts V $= A \times O = \frac{W}{A} = \sqrt{W \times O} = \frac{A}{M} = 10^{8}$ units.

Ohms O $= \frac{V}{A} = \frac{W}{A^2} = \frac{V^2}{W} = \frac{1}{M}$ $= 10^{9}$ units.

Mhos M $= \frac{A}{V} = \frac{A^2}{W} = \frac{1}{O}$ $= 10^{-9}$ units.

Coulombs C $= A \times t = \frac{V}{O} \times t$ $= 10^{-1}$ units.

Farads F $= \frac{C}{V}$ $= 10^{-9}$ units.

Volt-amperes V A $= V \times A = \frac{V^2}{O} = A^2 \times O = W = \frac{J}{t}$ $= 10^{7}$ ergs per sec.

Watts W $= V \times A = \frac{V^2}{O} = A^2 \times O = \frac{C \times V}{t} = \frac{J}{t} = 10^{7}$ ergs per sec. $= 737$ foot pounds per sec. $= 1019$ kilogrammetres per second $= 44{\cdot}236$ foot-pounds per minute $= \frac{1}{746}$ horse-power.

Joules J $= W \times t = V A \times t = C \times V = A^2 \times O \times t = \frac{V^2 \times t}{O} = 10^{7}$ ergs $= 2381$ calorie, or water-gramme degree Cent.

Candle-power (C.P.) $\frac{V \times A}{C.P.}$ = watts per candle.

BLIND MATHEMATICS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: It is one of the dangers which beset a mathematical treatment of physical science that from time to time instances will occur in which formulæ are handled after a blind fashion, and mathematical processes, sometimes simple, sometimes intricate, are carried out without any consciousness of the physical sense either of the first line from which the deduction is made, or of the last line which expresses the result arrived at.

Having recently met with an instance of this, which can scarcely be regarded as insignificant, I venture thus to trespass on your much sought-for space.

It is well known that when a short piece of fine platinum wire or carbon filament is made to form part of a powerful circuit, intense heat is developed in it, as we witness every day in an incandescent lamp. It has been found experimentally that the amount of heat so developed under varied circumstances is expressed by the simple formula, $H = C^2 R$. Had formulæ ceased here we should have been well-informed in the matter; but some expert mathematician, reflecting on the circumstance discovered by Ohm, that the current strength in a circuit was a function of the resistance in it, has simplified the expression by substituting for C the value $\frac{E}{R}$ derived from Ohm's formula, whence the heat formula becomes $H = \frac{E^2}{R^2} . R$, and finally $H = \frac{E^2}{R^2}$.

Had the author of this formula reflected on its meaning, he would have noticed how it implied that a minimum of resistance, such as that obtained by substituting a silver wire for the platinum, would yield a greater heating effect, whilst we know that the contrary is the case. Taking the mathematician on his own ground, he can be answered by pointing out that "R" in the heat formula, $H = C^2R$, is not identical with "R" in Ohm's formula, $C = \frac{E}{R}$, and, accordingly, he has made the false inference (rendered more conspicuous by an accent) that $\frac{R'}{R^2} = \frac{1}{R}$. Meanwhile, the fallacious deduction, $H = \frac{E^2}{R}$, has so far deceived the scientific world that a learned professor has aided us with a graphical representation of it, in which the perpendicular from the right angle of a triangle forms a mean proportional (like E) between the segments of the hypohtenuse (representing H and R respectively).

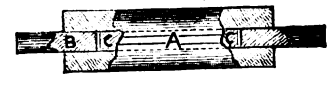
A heat formula will be useful only so far as it supplies a rule for determining the amount of heat that will be developed in any particular portion of a circuit. The formula $H = \frac{E^2}{R}$ gives such rule, but it is a false one. I am surprised at finding such an oversight in a work of the standing of "Ganot's Physics," where I accidentally met with it, and can only attribute the occurrence to the author not being duly conscious of the physical import of the symbols and expressions he was using.—Yours, &c., E. ALDRED WILLIAMS.

May 29, 1885.

CONTACT PIECES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It occurred to me if contact pieces for microphone transmitters were constructed as per sketch, a great saving of labour and a minimum amount of breakages in manufacture would occur.



Having constructed an instrument with three such contact pieces arranged parallel, and having obtained satisfactory results therefrom, perhaps this letter may prove of interest to some readers.

A is a piece of soft core arc lamp carbon, with about ¼in. of the core extracted from each end.

*BB are pieces of carbon, such as used for semi-incandescent lamps.

CC represent the unextracted core.—Yours, &c.,

London, May 25th, 1885. ST. GEORGE W. DAVEY.

* BB form loose contacts in A.

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MILITARY CABLES IN THE FAR EAST.

A short time ago we had to warn the investing public against a project then talked about for connecting South Africa direct with our Indian Empire. The objections to that scheme as a commercial undertaking were grave and conclusive. The route would be in very deep sea, the bottom of which has been but imperfectly explored; the sea itself would be practically closed by prevailing winds to all repairing ships for a great part of the year; and, what is of still greater importance, the commercial traffic between South Africa and India would not pay expenses. In all probability this very unpromising adventure was suggested by the prospects of war, an excellent reason for laying a military cable, but the very worst for speculating in commercial cable laying. We repeat here what we have had occasion to state more than once before that periods of political disturbance or warfare are bad for telegraphs as for all other trades, the loss of commercial traffic being far from compensated by increase of war telegrams.

But these objections do not apply to cable laying for Imperial defensive purposes; and it is with feelings of something akin to shame and dismay that we see these necessary measures apparently set aside as matters of no present importance. If we are to credit the Hong Kong correspondent of *The Times*, whose letter we partly reproduced in our last issue, nothing whatever has been done, and nothing is intended to be done, towards connecting such places as Hong Kong and Singapore by means of direct cables independent of a possibly hostile territory. The China Seas are by no means the only places where cable laying has been conducted on purely commercial principles, short lengths being used by preference, and points of intermediate landing chosen with natural regard for picking up traffic on the way. Consequently, if we cast our eyes over any telegraph map we see that not infrequently the through working, of coast cables especially, is at the mercy of some colony belonging to a foreign Power, who, if not benevolently neutral, might intercept our communication in time of war, and who, of course, would destroy it if that power were one of the belligerents.

Such a contingency is rather alarming for owners of cables; but the cost of duplicate, independent cables would be so great that the risk is run as the cheaper of two evils. But the case assumes a very different aspect when Imperial interests are concerned. Those interests demand at least as much attention as the commercial—the one set of interests, in fact, being bound up with the other. Recent events have attracted attention to our complete dependence upon the commercial system of submarine communication, and to the danger to our colonies, coaling stations, and even to our Indian Empire, consequent upon there being no State cables on which in time of war we could rely both for naval and military intelligence, and as alternative routes when commercial cables have been severed. It was hoped that amongst the plans for completing our naval defences this one of laying supplementary, if not purely military cables, which has been recommended by the highest authorities, would have received prompt attention. This expectation is not to be realised, it seems, if the case of Hong Kong and Singapore, which is really a very pressing one, may be taken as a proof of what the Government do *not* intend to do.

The Times correspondent points out, in reference to this particular locality, that to a nation like ourselves, with the enormous interests involved, one would imagine that we should recognise the absolute necessity of being forearmed by being forewarned, and this at any cost. Far from costing an enormous sum, it might have been accomplished by a small guarantee contributed by the Imperial Government, and the cable might have been working now if that condition had been complied with. This is what we have stated all along; and in most cases a company could be found to lay the cables and maintain them if the Government only went to the expense of a comparatively small subsidy. If the Admiralty will not lay cables for itself, the cheapest alternative is to help somebody else to lay them. But, according to *The Times* correspondent, the responsible officials have virtually replied that "If the colonies and Indian ports want torpedo boats and English cables they must pay for them themselves"; and he adds "that a terrible blunder will be committed if this attitude is persisted in."

Now that immediate hostilities have been avoided, we may be permitted to hope the blunder is not so terrible as this writer apprehends. But it is a blunder all the same, and one which could be more easily repaired in time of peace than on the outbreak of a war. There is still time to urge this consideration on the official mind; and we may hope that not only the Colonies, who are directly concerned, but Cable Companies who are indirectly interested, in obtaining these supplementary and independent cables will spare no effort to get them laid down. England has been spending enormous sums for the peaceful purpose of pretending she was going to

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fight; more than this, the net outcome of it all is to saddle the country, and her chief Imperial dependency with a vast outlay on defensive works now rendered indispensable. Compared with these charges, the cost of subsidising, or even of purchasing and laying a few cables, would be a mere bagatelle, and ought not to be grudged where the confidence and security of a widely scattered Empire are involved.

As to the Colonies paying for these necessities themselves, that is the sort of reply we should give to projects of long deep-sea cables, which have no great value except as aids to the Government. If the Government wants such cables let the Government pay for them. But it is not the right answer for an Imperial Government to make to its dependencies. It is outside our province to deal with the political aspect of a question of this kind; but one thing is obvious from commercial, to say nothing of ethical, considerations—namely, that as we founded these colonies in the interests of British trade, it would be suicidal as well as cowardly to leave them to fend for themselves when threatened by a foreign foe. We do not believe, however, that any such desertion is contemplated, but rather that if the proper steps are taken they will overcome the economic and short-sighted inertia of our rulers.

ON OBSERVING AND RECORDING THE VARIATIONS OF A CURRENT.

BY C. W. S. CRAWLEY AND F. B. O. HAWES.

(Continued from page 47.)

The value of the readings in volts at the galvanometer terminals was taken by a potentiometer method. A standard Daniel, A (Fig. 7), of about 4ω internal resistance was circuited

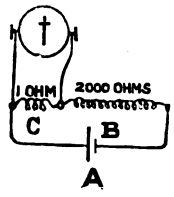

FIG. 7.

through two coils in series; one, B, of 2,000ω, and the other, C, of 1ω. The terminals of C were then also joined to the galvanometer terminals and the deflection of, say n, centimetre obtained. The E.M.F. at the terminals of the coil C is $\frac{1}{2000+1+4} \times 1{\cdot}079$ volt $= {\cdot}00538$ volt (the galvanometer resistance being so high that the joint resistance of the one-ohm coil and the galvanometer may be taken as 1ω). Therefore the constant of the galvanometer is $\frac{5{\cdot}38}{n}$ millivolts per centimetre.

This constant, of course, only holds good as long as the sensitiveness of the galvanometer remains constant—that is, so long as the "time of swing" of the needle remains unaltered; for the sensitiveness varies directly as, and the constant therefore inversely as, the square of that time. The time of swing was always taken as one-fifth of the time between the first and sixth passage of the spot over the zero mark in the same direction, after being deflected to the edge of the paper, and then allowed to swing freely. The time of one complete swing thus obtained will hereafter always be called "τ."

The constant for any time of swing having been found as above, it can be calculated for any other time. Thus let κ_1 be the constant for a time of swing τ_1 (that is 1 cm. deflection $= \kappa_1$ millivolts) and κ_2 the constant when the time is altered to τ_2 seconds per swing, then

$$\frac{\kappa_2}{\kappa_1} = \frac{\tau_1^2}{\tau_2^2} \quad \therefore \quad \kappa_2 = \kappa_1 + \frac{\tau_1^2}{\tau_2^2}.$$

It was found to be convenient to frequently alter τ so as to suit the various classes of currents under observation. Thus, a slowly varying current is best observed with a slow swing, say 10 or 15 seconds, while for one with sharp, short, variations τ would be made as small as possible, say 1 to 2 seconds, which is as quick as can be accurately followed by the pencil.

When taking a curve, if the variations are small compared to the total current, it is often convenient for their better observation to use a higher or no shunt on the galvanometer, and an inferred zero. Thus, suppose that with the "100" shunt and zero in the middle of the paper the current gives a deflection varying between 22 and 23 centimetres. Now let the "10" shunt be put on, the deflection becomes ten times greater, and the deflections will vary between 220 and 230 centimetres from the centre of the paper, and consequently not appear on it.

If, now, the controlling magnet of the galvanometer be turned so as to bring the spot again to the centre of the paper, the variations may be recorded on a scale ten times as large as before, zero being about 225 centimetres from the centre of the paper. When the controlling magnet is used in this manner it is important to know directly how much zero has been shifted, without having to calculate it from the deflection at the moment when the shunt was altered. This is more especially necessary in the case when the mean current slowly increases or diminishes, when it may again be necessary to shift zero owing to the position of the spot passing beyond the limits of the paper. The controller was therefore calibrated as follows:—A Daniell cell was circuited through a bare G.S. wire, stretched on a board, or wound on a cylinder, in series with a sufficient resistance to prevent polarisation. One terminal of the shunt box was joined to one end of the G.S. wire, and the other to a sliding contact on the wire. A measure was then placed on the paper, and the sliding contact adjusted till a deflection of exactly ten centimetres was obtained with the "10" shunt on, say to the left. The "10" shunt being now taken off the deflection became ten times as great, viz., 100 cm., the spot being off the paper. The controller was now turned round till the spot was brought back to zero. On one end of the controller a pointer was fixed, moving over an arc, and on the arc, at the spot at which the pointer stood, "+100" was marked. The battery being now reversed, the spot was again brought back to zero by turning the controller in the opposite direction, and "−100" marked at the spot where the pointer then stood, the normal position of the controller, *i.e.*, that position which, when no current is passing, allowed the spot to remain at the centre of the paper, being marked "0." In a similar manner the arc was graduated for every 50 cm. up to 500 both right (−) and left (+); so that, when taking a curve with inferred zero, all that was necessary was to bring the spot on to the paper and note down the reading of the pointer; thus +250 showed that the zero line was 250 cm. to the left of the middle of paper; −400, that it was 400 cm. to the right.

This method of observation, it will be seen, gives a very largely-increased range of observation. The paper used was only about 70 cm. broad, but by the above means slight variations in a large current were recorded on the same scale, as if the paper had been several metres wide.

It has been said that it was found convenient to work with different times of swing. This of course altered the effect of the controller. The correction can, however, be calculated on the same lines as that for the constant "κ_1" above. Thus, if the controller was calibrated when the time of swing was τ_1 secs., and this be altered to τ_2 secs., the reading of the controller in centimetres must be multiplied by $\left(\frac{\tau_2}{\tau_1}\right)^2$. Alterations in the time of swing were made by a second magnet, called the adjuster; as, the controller having been once calibrated at a certain distance from the needle, it was necessary to keep it fixed at that distance. The controller used was 90 cm. long, and pivoted on the ceiling 130 cm. vertically over the galvanometer. It was first strongly magnetised, and then tapped with a wooden mallet, so as to obtain a constancy of magnetisation, as suggested by Prof. Hughes.

When "τ" is frequently altered it will be found convenient

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to calibrate the controller not in centimetres, but in millivolts; for, as will be shown, this holds good whatever the rate of swing may be, thus saving calculation.

The constant was first taken as above, say, ·08 millivolt per centimetre, then 1 millivolt $= \frac{1}{\cdot 08} = 12{\cdot}5$ cm. The controller was then calibrated, using the G. S. wire as before, but taking deflections of 12·5 cm., 25 cm., &c., instead of 10, 20, &c. The marks on the arc of the controller then represented 10, 20, &c., millivolts, instead of 100, 200, &c., cm.

Now, a certain current of $\frac{n}{g}$ milliamperes through the galvanometer due to a difference of n millivolts at its terminals, always exerts a certain definite force on the needle when at its zero position, whatever the time of swing may be. The tan of the angle of *deflection* varies as the square of the time of swing, though the force exerted by the same current on the needle when at zero is always the same.

In the same way the force exerted on the needle by the controller when turned through a certain angle θ is always the same whatever the time of swing may be, though the number of cm. that zero is shifted varies as the square of that time. If, therefore, the controller, at a certain position counteracts the deflection due to n millivolts when the time is τ secs., it will do so whatever the time of swing may be. (Also, it may be noted, in passing, this calibration holds good, whatever distance the scale or paper be moved from the galvanometer.)

When thus calibrated the readings on the arc must of course be multiplied by the multiplying value of the shunt, if one is used.

This form of controller causes an error in working, and for more accurate determinations the authors have devised and used two other forms which overcome the difficulty.

With regard to the error. First, considering only the effect of the controller and current, and neglecting that of the earth and adjuster, let a b (Fig. 8) represent a needle (in plan) and O

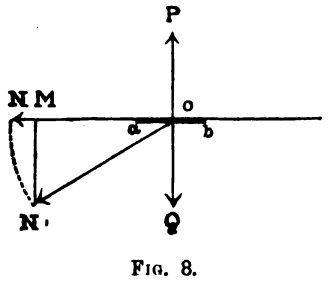

Fig. 8.

its centre of suspension, then the forces acting at O are equal and opposite. Taking those acting in one direction, let O N represent in magnitude and direction the force of the controller, which is vertically above the needle, and O P the force exerted by the current tending to deflect the needle from its original position in the line O N. Now, to counteract the effect of the current and retain the needle in its original position, the controller must be turned to a position, O N, such that, resolving O N into two forces, O M in the direction O N, and O Q at right angles to it, the latter is equal and opposite to O P. The time of swing, and therefore the sensitiveness, depends solely on the force in direction O N, that is on the component O M, which we may call the controlling component, O Q having no effect on the sensitiveness.

Calling θ the angle N O N through which the controller is turned, we have M O = N O cos θ, and the sensitiveness becomes greater in the ratio 1 to cos θ. Taking the forces of the earth and adjuster into consideration, and calling them E and A respectively, the variation of the controlling force when the controller is turned through θ^0 is from E + A ± C to E + A ± C cos θ, the + or − sign being taken according as the controller is set to act in conjunction with or in opposition to the earth.

The latter arrangement is the better, as will be seen from the following considerations:—

Call C_1 the controlling force of the controller when at zero, and C_2 the controlling component when turned through θ.

Then it has been shown that $C_2 = C_1 \cos \theta$; or writing $C_1 (1 - \cos \theta) = a$, then $C_2 = C_1 - a$.

Calling F_1 the total controlling force, which gives a swing of τ seconds with the controller at zero, and F_2 the force when the controller is turned through θ, then, when the controller is acting with the earth,

$$F_1 = E + A + C,$$
$$F_2 = E + A + (C - a);$$
$$\therefore F_2 = F_1 - a.$$

When the controller is against the earth, in order to maintain "τ" constant, the total controlling force, when the controller is at zero, must remain the same as before; and to get this the action of the adjuster on the needle must be increased by an amount = 2 C.

Calling F_3 the controlling force when the controller is turned through δ, we have

$$F_1 = E + (A + 2C) - C$$
$$(= E + A + C \text{ as before}),$$
$$F_3 = E + (A + 2C) - (C - a);$$
$$\therefore F_3 = F_1 + a.$$

Now, it is obvious that this is preferable to the last equation, for, to take an extreme case, let $a = F_1$. Then if the controller is with the earth the controlling force vanishes, while, if against the earth, the controlling force is only doubled.

It is thus evident that the above method of altering zero is unsuitable for large alterations, or when the total controlling force is small—that is when τ is large. For small alterations with fairly quick swing it is, however, a very convenient form.

The following two forms of controller have no effect on the sensitiveness, as their action in the needle is solely in the line P Q of Fig. 8. One form of controller used was composed of two magnets of equal strength and size, pivoted together at their centres, so that either their like or unlike poles could be brought together. The controller was placed vertically above the needle and the two magnets so geared together that if one were rotated through any angle in a horizontal plane the other was also rotated through an equal angle in the opposite direc-

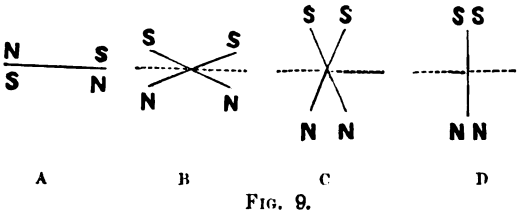

Fig. 9.

tion. A, B, C, and D (Fig. 9) show four positions of the magnets in plan, A being the zero position when the opposite poles are together and neutralise one another; D is the position of maximum effect when the like poles are together, and B and C intermediate positions. The needle underneath when at zero lies in the dotted line, and it will be seen that in every case the action of the controller on the needle is solely at right angles to the dotted line. It has therefore no effect whatever on the time of swing. This form was found very convenient when it was preferable to have the controller above the instrument; when it could be placed behind or in front another and

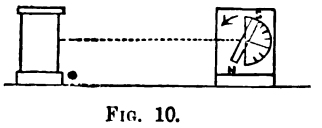

Fig. 10.

simpler form was used. A magnet, N S (Fig. 10), was pivoted so as to move in a vertical plane, and placed directly behind or in front of the galvanometer. The zero position is when the magnet is at right angles to the line joining its centre to the needle, its poles being then equidistant from the latter and neutralising each other. When, however, it is turned in the direction shown by the arrow the effect of the S pole gradually increases, while that of the N pole diminishes till the maximum

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is reached when the magnet is in the line joining its centre to the needle. By turning in the opposite direction the effect is of course reversed. The force, as in the duplex controller, acting solely at right angles to the needle, has no effect on the time of swing and sensitiveness. Both these forms were calculated in the same way as described for the first controller.

The shunt box as designed and used by the authors was of a new pattern, and by means of it shunts could be instantly put on the galvanometer and the correct compensating resistance thrown in at the same time, the necessity of being able to alter rapidly being caused by any sudden increase or diminution of the current; that of the compensating resistance, by the fact that the external resistance was often small compared to the resistance of the galvanometer, in which case, as is well known, the ordinary shunts are incorrect. Fig. 11 is a diagram of the galvanometer and shunt box. The dotted line shown joining the contact pieces, A *a*, is a brass bar with platinum contacts, pivoted at its centre, and, through the pivot, connected to the terminals T_5, which is joined to T_2 of the galvanometer.

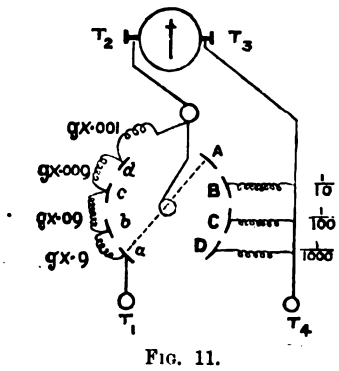

FIG. 11.

With the bar in the position shown the current enters at T_1, passes through the bar straight to the galvanometer and out at T_4, the resistance being g that of galvanometer. When the bar is turned so as to rest on B *b* the current enters at T_1, passes through the resistance marked $g \times \cdot 9$ to the bar, where it divides, part passing through the galvanometer and part through the shunt marked $g \times \frac{1}{9}$, the joint resistance of the galvanometer and shunt being $g \times \cdot 1$, and that of the compensator $g \times \cdot 9$; the total resistance remains $= g$ as before. In the same way, when the bar makes on C *c* the current passes first through $g \times \cdot 9$, then through $g \times \cdot 09$, and then to the bar and through the galvanometer and $\frac{1}{99}$ shunt, the total resistance being $g\,(\cdot 9 + \cdot 09 + \cdot 01) = g$ as before, and when on D *d* the 1,000 shunt is put on, while the resistance is $g\,(\cdot 9 + \cdot 09 + \cdot 009 + \cdot 001) = g$.

The contact piece *d* is joined to T_5 by a resistance of $g \times \cdot 001$; by this means, when the brass bar is not making on any of the contact pieces a resistance of $g\,(\cdot 9 + \cdot 09 + \cdot 009 + \cdot 001)$ —that is a resistance equal to the galvanometer—is thrown into the circuit, which it is often convenient to do.

OLD CABLE STORIES RETOLD.—VII.

BY F. C. WEBB.

(*Continued from page 513, Vol. XIV.*)

THE RED SEA AND INDIA CABLE OF 1859—60.

The shore-end was landed from the "Imperidor" on the 17th January, but was not immediately connected to the main cable, the ship lying with the main cable at bow sheave and shore end astern. On the 19th the ship was still in the same position, and the office fittings were being got into order by Messrs. Buffleb and Meyer, of Messrs. Siemens' staff. On this day the "Cyclops" left with Mr. Forde to arrange the landing place at Hellania (one of the Kooria Mooria Islands), which would form the next station. On the 20th, at night, it came on to blow, and the "Retribution's" anchor began to come home, and the ship to drive. Let go another anchor, and got up steam. By 4 a.m. of 21st blowing half a gale; at 7 a.m. wind veered more to the westward, bringing our stern so near rocks that we weighed one anchor, slipped the other, and steamed out to sea, and in doing so passed so close to rocks that a biscuit could have been thrown ashore. It was a very narrow squeak. On the 22nd, after standing on and off, towards afternoon wind dropped, and at 5 p.m. we came in again. The "Imperatrix" had gone round to Telegraph Bay, as we christened the bay where the ends were landed. The "Imperador" during the gale had swung to her anchor, and dragged the shore end off the beach. This end was landed again by light of blue lights, &c. On the 23rd the "Imperidor" commenced paying out shore end and picking up main cable till the three miles of shore end were payed out, and at 4 p.m. final splice was made, thus completing cable between India and Arabia.

The "Imperatrix" this day landed end of shore end of the Muscat-Kooria Mooria section. On 24th left Muscat in the "Retribution," and the "Imperatrix" began to pay out. Paid out till 11 a.m. (15 miles out), when a stoppage occurred, and the "Imperatrix" made signal, "I must cut cable." We ran down to them. They said they had under-run cable one mile, and would be ready in half an hour. About 4:30 they sent a boat to under-run back again. When about a mile back the boat made a signal, and another boat went to them. It was now dark, so we anchored with a kedge; then weighed and dodged round the "Imperatrix," still at anchor. On 25th, at 0:30 a.m., the "Imperatrix" began paying out. When eight miles more were out (making 23) stopped, and began to haul back by hand. Then she cut cable and buoyed end, and ran back to last night's anchorage, and dredged there. The "Imperidor" arrived from Muscat. Mr. Newall asked commodore also to dredge for cable in the "Retribution." All three ships dredged with boats astern until 8:45 p.m. The "Imperatrix" hooked cable, and made signal with blue lights. On 26th the "Imperatrix" had cut cable, and got part leading to shore over stern. The "Imperidor" picked up isolated section, and at 4 p.m. the "Imperatrix" began paying out, the "Retribution" ahead. At 5:35 got to point where the "Imperatrix" stopped yesterday, viz., 23 miles from Muscat. Going seven knots in about 40 fathoms. On 27th, 4 a.m., passed Ras-el-Had, about 2½ miles from land. On 28th, 2 a.m., abreast of island of Myseera. At 45 minutes past noon the "Retribution's" engines broke down, and she instantly made all sail. The "Imperatrix" made the signal, "Well done, brave old commodore." We concluded this message was composed by the lady on board. Disconnected starboard engine, and by 7 p.m. were steaming with port engine and going seven knots. The "Imperatrix" had passed us and gone on a long way ahead. On 29th got abreast of the "Imperatrix," which ship was brought up seven miles from landing place at Hellania, and was splicing on shore end and was going to pay out at night. On 30th we went into regular anchorage at 9 a.m. At 11:30 a.m. the "Imperatrix" began to pay out shore end and landed it same day.

At Hellania there is a magnificent bluff, higher by some hundred feet than the Rock of Gibraltar. On the island there were about a dozen miserable, half-starved Arabs, who live on fish, which abound. One day the officers of the "Retribution" took the ship's Seine net ashore, and at the first haul got a boat load of fish of very great variety. The doctors were eagerly consulting their books on natural history, and made out some of the species, amongst which was the toad fish, which when rubbed swells into a ball. The huts of the Arabs resemble nothing so much as what schoolboys make when playing at "making houses." They were not more than about 4ft. high, and the walls, enclosing about a space of 7ft. by 7ft. of court yard, were about 1ft. 6in. high. For what purpose these can be constructed I am at a loss to imagine, as I cannot call to mind any animal that could possibly be kept out by them.

The office at Hellania was a tolerably well designed building, in wood, with detached buildings for the staff. A party of Royal Marine Artillery from the "Cyclops" were landed to guard the station, as the Arabs from the main land (about seven miles off) occasionally came across and plundered the unfortunate islanders, carrying off anything of value, and sometimes some of the fair sex.

I was told by Mr. Brunton that I could not test the Kooria

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Mooria-Muscat section, as the end was buried at Muscat. The arrangements for testing whilst paying out included a clock arrangement which put cable to instrument, insulated it, put it to earth or to battery for a certain number of minutes out of each hour. This arrangement I had used for several years on the Hague cables, it having been suggested by Mr. Latimer Clark, the only difference being that in our case it did not put line to instrument, as we had no clerk at the end at all.

On Feb. 4 the "Imperatrix" landed end of Kooria Mooria-Aden section at 8 p.m. At 2 p.m. we started in "Retribution," and went slowly on towards Aden, but the "Imperidor" and "Imperatrix" did not follow. At sunset we buried a poor boy who died the day before during amputation of the leg, rendered necessary by inflammation of the bone. Laid to for night. On February 5, 8 a.m., "Imperatrix" paying out, with "Imperador" in attendance; at about 10 they came up to us. On 6th passed Ras Furtak. On 7th "Imperatrix" made signal:—"I must cut cable." "Imperatrix" backed astern and hauled in. Told us to go on. She made signal:—"All well." On 8th, 10 a.m., passed Maculla, distant 10 miles; 1:30 p.m., brought up in a sandy bay, 25 miles south of Maculla. "Imperidor" there at anchor, had got boats away, and had weighed buoy on end of cable payed out from Aden months ago; 3 p.m. "Imperatrix" arrived, and brought up ahead of us. She had only a quarter of a mile of cable left in her. She got end of part leading to Aden on board, and spoke to Aden and sent messages, but found defect between ship and Aden, but thought it near Aden. On 9th still at anchor. Sent paddle-box boats to coal "Imperatrix" from "Imperidor." They were testing all day. Distance from Aden about 240 miles. Nobody was allowed to land here, as Mr. Rassam (of Abyssinian fame), who was with us as political agent, pronounced it to be unsafe.

On the 10th in same position. At 8 a.m. the "Imperidor," with Mr. Newall and Mr. Meyer, left to grapple up the cable 20 miles nearer Aden for testing purposes. They cut the cable in the evening, and found the fault in the 20 miles, so buoyed—the end of part leading to Aden—and commenced picking up towards us. On 11th still at same anchorage; the "Imperidor" appeared in sight picking up, and soon brought up near the "Imperatrix," and spliced on some new cable she had on board to the part paid out from Kooria Mooria by the "Imperatrix," which ship being the free one now started off to pick up buoy on end 20 miles off. The "Imperidor" started paying out. We followed and passed, the "Imperidor" stopped short of her distance. We afterwards passed "Imperatrix" at the buoy on end of part leading to Aden. Anchored near her, 45 miles south of Maculla.

On the 12th the "Imperidor" arrived, and made final splice, thus completing the first line of telegraph between India and Aden. We went on for Aden. Passed the Indian Navy ship "Aukland," which saluted the commodor's flag with eleven guns. We were going to return the salute when the key of the magazine could not be found, and there was general silent consternation, for somebody was to blame, and the purser quietly whispered to me, "suppose a Russian frigate was alongside." The key was at last found, and the salute returned, but the "Aukland" was nearly out of sight.

On the 13th we arrived at 8 a.m. at Aden. Found line all right to Kurrachee; but broken down to Suakim. Prof. Gordon came on board, having been laying a cable at Batavia. The "Imperidor" and "Imperatrix" arrived at 11 a.m. On the 14th the "Cordilliere," the French frigate which had been at Muscat, arrived.

A number of salutes were fired, we saluted the Brigadier in charge of Aden, and returned the salute of the French frigate; and whilst this was being thundered forth by the main deck guns we read below our letters from home.

(*To be continued.*)

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The directors of this company yesterday declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income tax, for the quarter ended 31st March last, and payable on the 24th inst. The company's books will be closed from the 17th to 23rd inst., both days inclusive.

IMITATION OF THE PHENOMENA OF ELECTRICITY AND MAGNETISM BY MEANS OF LIQUID OR GASEOUS CURRENTS.*

BY M. C. DECHARME.

I have been engaged for several years in a series of experiments having for their object the imitation, by means of hydrodynamics, of the principal phenomena of electricity and magnetism. I have studied the analogy of these two orders of phenomena successively in their mechanical, physical, chemical, and physiological effects, with a view to obtain new proofs in support of the hypothesis in which the electric movement is considered as the undulatory movement of a fluid (ether or ponderable matter). The following is an abstract of the numerous experiments which I have already made:—

1. MECHANICAL EFFECTS.

Hydro-magnet.—After having adapted to a pipe, alimented by the waters of the town, a disc (Fig. 1, No. 1) (of $0^m{\cdot}05$ to $0^m{\cdot}08$ in diameter) surrounding the aperture of the tube, I found that upon approaching the disc to the bottom plate of a vase, either empty or full of water, it produced a sensible attraction, the energy of which depended upon the force of the current and the breadth of the disc. This attraction does not bring the two surfaces to a point of actual contact, for the reason that the liquid flows to the circumference with small speed; but if the tube be raised the resistance due to the differences of pressure which are exercised upon the exterior surface of the disc and in the intermediary space can be determined. This experiment gives a perfect imitation of an electro-magnet which is active so long as an electric current passes through it, and which becomes inactive on its cessation.

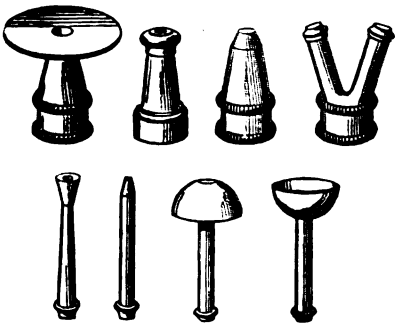

FIG. 1.

If the thick-edged nozzle (Fig. 1, No. 2) be changed for one with sharp edges (Fig. 1, No. 3) the attraction is changed to *repulsion*. These two opposite effects are at their maximum when convergent nozzles are used. It can thus be seen how it is possible to produce, with the two kinds of nozzles, hydro-magnets of opposite poles, the one attractive and the other repulsive.

Hydro-dynamic Vibrations.—In this case the pipe is supplied with a thick-edged nozzle (Fig. 1, No. 2) (of $0^m{\cdot}004$), or with a thin-edged nozzle (of $0^m{\cdot}001$) (No. 3). If it be lifted a little, in order to induce the movement, and then abandoned to itself, it sets up a number of vertical vibrations sufficiently rapid to produce a sound (la_1). If the tube be pressed the vibratory speed is augmented.

This effect is analogous to that of an electro-magnet under the influence of an automatically interrupted electric current, as in the case, for instance, of the coils of an electrical bell in full action. If now the vibrating tube (Fig. 2) be taken in the hand, it seems in every way to resemble a true electro-magnet, so rapid and so strong are the successive effects of attraction and repulsion. They are exactly similar to those of magnetisation and demagnetisation, for the instantaneity of action and increase of energy are in accordance with the diminution of the distance. This experiment not only gives an abstract imitation of electro-magnetic phenomena, but is an effective realisation of the movements produced by electro-

* From the *Journal de Physique*.

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magnets under the influence of currents regularly interrupted. They are, in my opinion, susceptible at the same time of receiving dynamic applications. It is easy in point of fact to imagine the mechanical arrangements which would convert the vibrating tube into a small high speed motor, a meter, or an interrupter.

Hydro-induction.—The fundamental thing which is the cause of the vibrations in the preceding experiment is that which is produced in the tube at the moment of the *interruption* or of the *passage* of the liquid current. At the moment when the tap which gave passage to the liquid jet was *opened suddenly* there could be felt in the tube held in the hand a pronounced movement of *recoil*, and when the tap was *closed rapidly* a contrary movement, which tended to carry the tube *forward* was noticeable. These effects are analogous, the first to that of the reaction of a car, the second to the blow of a hydraulic ram, produced by the sudden stoppage of the long interior column of liquid. In comparing the liquid current to a voltaic *inducing* current, and the envelope, the tube, to the wire *induced*, and surrounding the inducing wire, the phenomena which have been described are analogous to those that an electric current alternately opened and closed produces in the induced wire. Again, the hydro-dynamic movements are *instantaneous*, as with induced currents—that is to say they are manifested at the moment of the passage, or of the interruption of the current. During its entire duration there is no dynamic effect. It is known that when an inducing electric current *begins*, *increases*, *diminishes*, or *ceases*, it originates in the wire induced a current *inverse*, *increasing*, *decreasing*, or *direct*. It is absolutely the same with liquid currents, a fact which is by no means difficult to verify.

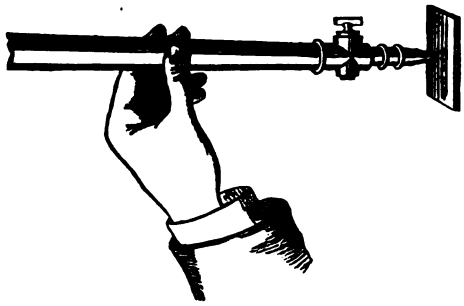

FIG. 2.

Reciprocal Action of Currents.—For these experiments I have adopted the following arrangements :—A branch, such as Y (Fig. 1, No. 4), is screwed upon the waterspout and carries two india rubber tubes of equal dimensions, at the extremities of which are adapted nozzles of diverse forms, cylindrical, conical, hemispherical, &c. For the liquid currents issuing (in the air or in the water) by two tubes *without nozzles*, currents parallel in the same or in a contrary direction, angular currents, &c., I have found the same laws as for electric currents. But with tubes provided with thick-edged nozzles or with discs, one at least of the tubes being mobile (Fig. 1, No. 5), the results are entirely different; two currents of contrary direction and directly opposed to each other are attracted (in the water), when the distance which separates the openings is not more than $0^m \cdot 01$ approximately, and this attraction increases rapidly, accordingly as the distance diminishes. If the discs are removed a considerable resistance and a number of strong vibrations can be felt, more especially when convergent nozzles are used. If the nozzles are disposed angularly or excentrically an *axial force* restores the currents to parallelism and to the coincidence of their axes. With nozzles with slender or sharp edges (Fig. 1, No. 6) there is always *repulsion*, *axial direction*, and *vibrations*. If the currents (directly opposed to each other) be diverted from their position of equilibrium, that which is mobile oscillates in the same manner as the needle of a compass when under the influence of a bar magnet. The more the nozzles are soft and the tubes flexible, the more the oscillatory phenomena are apparent. Nozzles, with curved edges, concave or convex combined two and two with the preceding, have given varied effects, among which we may mention the following :—When a *concave* nozzle (Fig. 1, No. 7), was adjusted to one of the tubes of the branch, and a convex nozzle (Fig. 1, No. 8) to the other tube, they produced a *strong attraction*, which was sensible at a distance of $0^m \cdot 05$. The axial direction is equally pronounced with this system.

Repulsion of the Consecutive parts of the same Current.—In order to demonstrate that the consecutive parts of the same current repulsed each other, I devised an experiment which is simple and demonstrative. A small india rubber tube of great flexibility (of $0^m \cdot 12$ to $0^m \cdot 25$ in length, $0^m \cdot 004$ to $0^m \cdot 005$ interior diameter, and $0^m \cdot 0015$ to $0^m \cdot 002$ thick) was adapted directly to a tube alimented by the waters of the town. When a current of water flowed by the small tube, which was held in the hand, there could be felt a strong traction of the tube, a distinct and pronounced *recoil*. In order to determine the value of this force I attached to the free end of the small tube, which was held vertically, a wire carrying a weight, and found that the reaction was capable of lifting 140 grains, or with perfect ease a weight of 100 grains. On releasing the small tube it twisted in different ways and threw water in all directions. Placed in the liquid it wriggled in a most lively manner, and had a tendency to press against the bottom and sides of a vase. The tube, reduced to $0^m \cdot 10$ in length, vibrated spontaneously with great quickness. All these effects are evidently due to the repulsion of the consecutive parts of the liquid current; they thoroughly demonstrate the existence of this reaction, and give the measure of its energy.

(To be continued.)

NOTICES OF BOOKS.

Anleitung zur Errichtung und Instandhaltung oberirdischer Telegraphen-und Telephon-Linien aus Lazare Weiller's Patent Silicium-Bronze-Draht. By T. B. GRIEF. [L. W. Seidel v. Sohn, Vienna.]

In this handy little book the author records a number of facts regarding the mechanical, chemical, and electrical qualities of Weiller's silicium bronze, and the experience of practical electricians in laying telegraph and telephone lines of this material.

The copper used in the manufacture of these wires is that known under the name of "Lake Superior," and is specially pure. The conductivity of silicon copper wire is said to be equal to that of silver, and the author recommends the use of it for submarine and underground cables, and for electrical transmission of power. For overhead lines silicon bronze wires are preferable, partly on account of their greater tensile strength, and partly because they withstand for an almost unlimited time the oxidising influence of the atmosphere. A slight coating of oxide is indeed formed, but this does not extend into the body of the wire, and it acts as a kind of insulator. As in all similar alloys, high conductivity and high tensile strain are to some extent antagonistic, but the latest brands of silicon bronze seem to fulfil both requirements far better than phosphor-bronze or manganese bronze. Thus we see from a curve, giving tensile strain as abscissæ and conductivity as ordinates, that a conductivity of 100 per cent. can be obtained with a material whose tensile resistance is 30 tons per square inch, or 80 per cent. at 37 tons, 40 per cent. at 53 tons, and 20 per cent. at 75 tons. From these figures it will be seen that with a breaking strain equal to that of ordinary iron wire a silicon bronze wire has about the same conductivity as pure copper.

Four principal qualities are made and used for the purposes specified in the annexed Table A.

Extended tables are given for each brand, designed to facilitate the choice of wire for each special purpose, and to avoid the trouble of long calculations. These we cannot, however, reproduce for want of space. An interesting table, com-

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paring the weight of steel and iron wires with silicon bronze wires electrically equivalent to them, is also given, of which Table B is an abstract.

On account of the reduced weight of silicon bronze, as compared with iron, and its greater tensile strain, a considerable saving can be effected in long telegraph lines. Not only can lighter poles be employed, but the increase of span results in a considerable reduction in their number, and the cost of carriage and erection, both for wire and poles, is also materially lessened. From the estimate given by the author in detail, we note that a line of 1,000 miles, complete and ready for traffic, costs in iron about £32,000, and in silicon bronze about £22,000. Such calculations are, however, sometimes misleading, and to put the matter on a practical basis the author should have made his estimate, not for a single line in which the cost of poles forms a very serious item of the total cost, but for twenty or more lines carried on the same poles.

TABLE A.

Brand.	Conductivity in comparison to pure copper.	Breaking strain. Tons per square inch.	Specially suitable for
A	97 % to 99 %	28 to 30	Aerial telegraph lines, submarine cables, wires and cables for electric lighting and transmission of power.
B	80 % to 84 %	35 to 37	Long telegraph lines and long spans.
Extra A	42 % to 44 %	51 to 55	Short telegraph and long telephone lines, military telegraphs and temporary lines.
Special B	20 % to 22 %	71 to 74	Very long spans, wire ropes, sounding lines for great depth.

TABLE B.

Material hitherto used.			Equivalent Silicon Bronze Wire.	
Quality.	Diameter in Mils.	Weight per Mile in lbs.	Diameter in Mils.	Weight per Mile in lbs.
Cast Steel	7·8	95·5	3·9	24·7
Steel	13·8	265·0	5·9	55·8
Iron	19·6	552·0	7·9	95·5

The book contains very minute instructions for the putting up of lines, and a description, with illustrations, of the tools required. English electricians will probably be astonished to find that Herr Grief gives instructions how spirit of salt must be used when soldering joints. He does not absolutely condemn its use, but merely mentions resin as a somewhat safer material. We should have thought it by far the best not to tolerate the use of killed salts under any circumstances whatever.

The attachment of lines to the insulators, the different forms of the latter, as also poles and other supports for a large number of wires, are fully treated. The chapters on lightning conductors and on the precautions to be used to avoid a singing noise in the wires being transmitted to the building might with advantage have been enlarged. On induction nothing at all is said. The book is well printed, and contains a good index.

ATMOSPHERIC ELECTRICITY.—Mr. L. Palmieri has found that the electricity is always positive when, within a circle of 140 kilometres in radius of the place of observation, neither rain, snow, or hail is falling. If negative electricity is observed with a clear sky, downfall at some little distance may be inferred.

PROFESSOR TYNDALL ON THE SOURCES OF ELECTRICITY.

Prof. Tyndall, in his sixth lecture, reminded his audience that in the previous lecture he touched on the subject of pyro-electricity and on the subject of thermo-electricity. As the names indicated they were both connected with heat—electricity developed by heat. Pyro-electricity was produced when crystals which had been heated were becoming cool. Tourmaline was an eminent example of these crystals. They found one electricity at one end of the crystal and another, an opposite electricity, at the other end. This pyro-electricity was developed upon insulators—crystals which were insulated—non-conductors. Thermo-electricity, on the other hand, was developed by heating the junction of two different metals. Bismuth and antimony were eminent examples of this. If they were soldered together and brought into contact there was an electrical current. Thermo-electricity was discovered by Seebeck, of Berlin, in 1826. Five years rolled by, and perhaps a discovery which quite ranked with the discovery of the voltaic pile was made within the walls where they were then assembled. In November, 1831, Faraday communicated an ever-memorable paper on induced currents to the Royal Society. Faraday took a round piece of wood, such as that which he (the lecturer) then held, and rolled around it a coil of copper wire over-spun with cotton. He (the lecturer) explained that in the example before them there was a coil within next to the wood, of which these two were the ends, and there was another coil coiled round that, and separated from it, in Faraday's case—not only separated from it by the over-spinning of the wire, but separated the one coil from the other by a mass of paper, over which the voltaic current which Faraday used could not pass. How Faraday came to think of the experiment he could not tell. He remembered once an eminent German saying to him "he smelt it." Faraday had an instinct towards the secrets of nature in putting things together so as to ask nature the proper question and obtain the proper answer. He made this experiment. He connected the two ends of the wire forming the interior coil with a voltaic battery, and he connected the two ends of the outer coil with a galvanometer. He knew that if he got any electric current he would be able to detect it in the magnetic needle. He made various experiments, and it was on the point of eluding him, and it might have eluded a man of less skill, observation, and power than Faraday. But he expected some permanent effect to be produced. His mind was awake and his eyes open to every action of the apparatus, and he noticed at the moment when he followed the circuit which communicated with his battery with the inner coil, the galvanometer connected with the outer coil made a little move. He watched it, and found that it was always in the same direction, and that it was only a momentary shock of the needle which was thus produced. He interrupted the circuit, and saw the current in the opposite direction. He also made this experiment :—There was a voltaic coil (indicating it) covered with copper wire, and varnished with shellac. Having placed it in a position described, he said that they had now a current passing from the battery through this coil. If he allowed his hand to rest on the coil any time he would know that a current was passing. The action was a very small one, and they would have to pay considerable attention to the needle. [Experiment.] They found a little tick—just what Faraday experienced. He brought one coil on the other, and caused the coil through which the current flowed to approach the coil disconnected from the battery. He now brought it down [experiment], and they would observe the small motion of the needle. That was what Faraday observed, and they would see that it was only a momentary action. He would now lift one coil from the other, and they would then observe a motion of the needle in the opposite direction, as Faraday noticed it. [Experiment.] They would remember what he said on a former occasion about the smallness of the germs from which great scientific discoveries arose, and also great practical developments. It was from the little seedling which they had just seen that the electric light had been developed. The incandescent and arc lights and all the companies formed in connection with them had been founded on that little discovery of Faraday; and Faraday himself, who made this discovery, never obtained a shilling by it. He (the lecturer) would not think of saying anything disparaging of those who brought such discoveries to practical use, but he again maintained that men like Faraday were the discoverers, and that it was the office of practical men to develop the discoveries made by such investigations. Mr. Cotterell had placed in his hand a common coil of wire, just as it had come from the instrument maker, a coil of covered copper wire. He held that coil and before him there was a magnet. In his last lecture he spoke of the relationship between electricity and magnetism. He took that magnet, and, putting its pole through the coil, produced a current in one direction; taking it away produced a current in the other direction. He would now make a little experiment in a manner which he thought would cling to their

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memories. The direction of the current depended on the pole of the magnet thrust through. One pole produced a deflection in one direction, and the opposite pole produced a deflection in the other direction. [Experiment.] There was another point developed by Faraday. He used a ring of iron. He found that if, instead of coiling his two coils of wire round a piece of wood, he coiled one of them round a coil of iron and connected that coil with a magnet or battery, that coil within the coil became highly magnetised. He would now ask Mr. Cotterell to show him certain lines—which perhaps every boy and girl present had seen—to which Faraday attached supreme importance. He made some beautiful experiments with the assistance of the screen, illustrating what Faraday called the lines of magnetic force, which, he observed, were very well known before Faraday's time, and called magnetic curves. Proceeding, he reminded them that the earth was a magnet. The space around a magnet was a magnetic field—that was to say, a region within which magnetic force exercised the needle. He was going to say that we all lived in a magnetic needle, and were all permeated by these lines of magnetic force. If he could scatter iron filings in that room, and they were not attracted by the earth—if they did not fall to the earth—they would arrange themselves in lines such as he would now point out. Displaying a wheel, he observed that it was made of coils of copper wire. He spun it round, remarking that he tried to make the axis of the spinning coincide with the earth's line of force. If he turned the wheel in one way they would see that there was next to no action on the needle, but if he turned it the other way they would observe that the needle went obediently and would go to 90 degrees. Faraday followed through all his life these lines of force, which led him to all his great discoveries in electricity and magnetism. The experiments which they had just seen should impress them with the extreme importance of the action of those lines of force. He had an instrument there which would enable him to describe to them exactly the experiment made by Faraday. They saw that he held one coil—the interior coil—and there was the exterior coil, and that exterior coil he would connect with the galvanometer. He would attach the galvanometer to the outer coil, and he would now pass a current from a battery of ten cells. He had connected one coil with the battery and the other with the galvanometer. [Experiment.] There was, as they saw, the same motion, small, but very perceptible. If he took off the current the needle went back. He repeated the experiment with a little more current from the battery. He then called attention to an instrument which he described as "the beautiful reflecting galvanometer of Sir William Thomson," which he explained, and with the assistance of which he made some instructive and pleasing experiments. It had been his wish to show them how easy it was to produce these induced currents. By a few small experiments they had had laid bare the whole origin of this magneto-electricity, or discoveries of induced currents by Faraday. Faraday, with the prophetic vision which belonged to him, said "I am more anxious now to discover new facts and new principles, however small the facts may be, feeling perfectly sure that those facts will get their due development hereafter." It was prophetic, for, as he (the lecturer) had said, all that they now saw in connection with the electric light had come from the small germ which they had seen. Soon after Faraday's discovery it was sought to make machines to utilise these induced currents. He then exhibited a machine, which he said had been made for nearly half a century, and with which he made an experiment. They were indebted to Mr. Wilde, of Manchester, who made a great step forward in this direction. With the assistance of Mr. Wilde's machine and Siemens's armature he made some interesting experiments. He would now pass to another matter, and this was the only step made since Faraday's discovery. It was announced simultaneously by the late Sir W. Siemens and the late Sir Charles Wheatstone, and their discovery was brought before the Royal Society on the same night. He explained the working of the machine, and showed how, by a series of actions between coil and coil, the magnetism was exalted to an enormous extent. He had now again to refer to the influence of resistance in producing heating effects outside the circuit. He exhibited a wire composed of two metals—silver and platinum—through which he intended to send the self-same current, and they would observe that the wire would be heated in spaces, and that it was not uniformly heated throughout. The same result was not produced throughout, in consequence of the resistance of the brighter metal. He next directed attention to a bulb from which the air was excluded, and showed some carbon filaments, which he said were used in incandescent electric lamps. Having shown one of Edison's and one of Swan's lamps, the lecturer stated that they had subsequently had the aid of Mr. Crompton, who had placed the lamps round the gallery of the theatre (and with which the theatre was lighted, whenever necessary, in a most effectual manner). He next called attention to the Gülcher lamp, with which he showed a beautiful arc light, explaining how the two carbon points were consumed as the electric current passed through. The carbons, he stated, would burn for eight hours without renewal. Various other gentlemen had helped him in the delivery of his lectures, and he was specially indebted to the Messrs. Siemens, who were represented now by Mr. Alexander Siemens, who had provided him with a dynamo, which was downstairs, and which generated the powerful currents, effects of which they had seen. Having cut through a piece of wood by a circular saw which was set in motion, he thus showed another use to which electricity could be applied.

Prof. Tyndall, who in the course of the lectures had been warmly applauded, here announced that he had come to the end of his task, which had afforded him very great pleasure. He thanked them for the great attention which they had paid, and he asked them not to thank him only, but also Mr. Cotterell, who had afforded him such great assistance. As promised by Prof. Tyndall in his prexious lecture, a copy of the work which he then mentioned—"Notes of a Course of Seven Lectures on Electrical Phenomena and Theories," delivered by him in April and June, 1870—was distributed to many who had attended the course.

RELATION BETWEEN THE ELECTROMOTIVE FORCE OF A DANIELL CELL AND THE STRENGTH OF THE ZINC SULPHATE SOLUTION.*

BY H. S. CARHART.

The investigation here described was carried out in the physical laboratory of the University of Berlin in the spring of 1882, and was undertaken with a view to ascertain whether the variation in the strength of the zinc sulphate solution surrounding the zinc plate of a Daniell cell affected the electromotive force, and to what extent.

It is well known that different experimenters have found different values of the electromotive force of a Daniell element. Thus Sir William Thomson found a value of 1·122 volt; Latimer Clark, 1·11; Kohlrausch, 1·138.† These different results may be partly due to difference of method; but it is easy to ascertain that slight changes in the condition of the plates or in the concentration of the solutions modify the value of the electromotive force to an appreciable extent. The method employed in this investigation was essentially the compensation method of Poggendorff.‡ The two poles of the battery A, the electromotive force of which

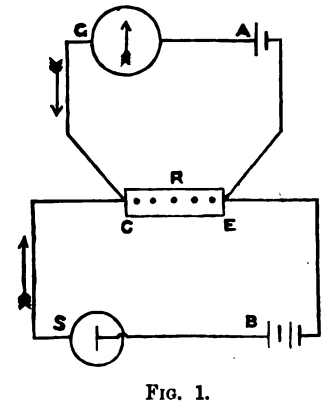

FIG. 1.

is required, are connected with two points, C E, of a second circuit containing a battery, B, of higher electromotive force than A. The resistance between C and E is then varied by means of the rheostat R, till no current flows through the circuit of battery A. The difference of potential between the points C and E is then the electromotive force to be measured. By Ohm's law, the product of the resistance inserted between C and E and the strength of the current in the main circuit equals the difference of potential between the two points, or the electromotive force of A.

The current was measured by a silver voltameter, S, with pure nitrate of silver. The resistance employed at R was in Siemens units. The deposition of silver was continued for ten minutes; the cup was then washed with great care, dried in a hot air chamber, and weighed after cooling, fractions of milligrams being obtained by observing the swing of the pointer.

The Daniell cell consisted of a U tube of the form employed by Kohlrausch in measuring the resistance of electrolytes,§ the bend of the tube being much smaller than the two branches. The lower portion was first filled with a saturated solution of pure zinc sulphate; saturated copper sulphate was then added to one branch, and a percentage solution of zinc sulphate to the other. The sulphates were so added that the surface of separation between two solutions in contact was quite clear and sharp. This was effected by first placing a small disc of cardboard on the surface of the liquid in the tube, and then carefully pouring the other

* From the *American Journal of Science.*

† Everett's "Units and Physical Constants," p. 146.

‡ Wiedemann's "Elektricität," p. 633.

§ Wiedemann's "Elektricität," p. 590.

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liquid on it from a pipette. No sensible diffusion took place during the time required to make the observations.

The galvanometer in the circuit of A was a sensitive one and was observed with a telescope and scale at a distance of about two metres. After a little experience a balance was readily obtained by the greater or less immersion of the silver plate in the nitrate of silver solution of the voltameter; and it was tested from time to time during the deposition of the silver and corrected if necessary. The galvanometer never showed a deflection of more than a few scale parts—perhaps five of the millimetre divisions. The electromotive force of A was thus measured with minimum liability to polarisation, and by a method entirely independent of the internal resistance of the cell. The only resistance required is that between C and E, and this can easily be measured by means of a rheostat.

The temperature of the rheostat and of the cell was observed at every trial. The extreme limits of variation in the temperature of the cell was 3° ·2 C.

The table exhibits the results; but the final reduction, as shown in the last column, was not made till after the recent report of the Paris commission on the legal ohm, and the publication of the results of Lord Rayleigh's experiments with the silver voltameter.* The values of the electromotive force, given in the column next to the last in arbitrary units, were reduced to volts as follows:—

Per cent of $ZnSO_4$	Temp. of R'eostat.	Resist. in Siemens Units.	Silver deposited in one min.	Prod. of resist. & silver.	Cor'd. for temp. of rheostat.	Mean value of product.	E.M.F. in volts.
			mgs.				
0	20°	11	6·727	73·997	73·997	73·997	
1	18·8	11	7·277	80·037	80·000	80·000	1·125
3	18	11	7·339	80·729	80·664	80·584	1·133
	19·5	12	6·710	80·520	80·504		
5	17·8	11	7·423	81·653	81·581	81·216	1·142
	17·3	11	7·358	80·938	80·851		
7·5	17·3	11	7·239	79·632	79·546	79·620	1·120
	18·3	11	7 250	79·750	79·694		
10	17	11	7·224	79·464	79·369	79·490	1·118
	19·3	11	7·239	79·634	79·612		
15	20	11	7·219	79·409	79·409	79·305	1·115
	18·3	11	7·205	79·255	79·201		
20	17·3	11	7·170	78·870	78·785	79·008	1·111
	17·5	11	7·210	79·310	79·231		
25	16·3	11	7·199	79·189	79·072	78·997	1·111
	16 6	11	7·184	79·030	78·923		
						Mean	1·122

The ratio of the Siemens unit to the congress or legal ohm is 100 to 106, or, 50 to 53. According to Lord Rayleigh a current of one ampere deposits 4·025 gms. of silver in an hour, or 67·08 mgs. a minute. Therefore if C, R, and E represent current strength, resistance, and electromotive force in amperes, ohms, and volts, and e the electromotive force in the arbitrary unit of the table, we have the following equation,

$$\left(R.\frac{53}{50}\right)(C \times 67{\cdot}08) = e\,;$$

$$\text{whence } R\,C = \frac{e}{\frac{53}{50} \times 67{\cdot}08} = \frac{e}{71{\cdot}105} = E.$$

It is only necessary then to divide the quantities in column seven by 71·105 to reduce them to volts.

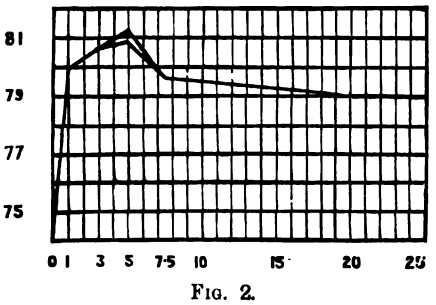

FIG. 2.

The method employed is amply sustained by the results obtained with a Latimer Clark standard cell. Two trials gave the same result. I give only one of them.

Time of deposition of silver	10 min.
Resistance between C and D	20 S. U.
Temperature of rheostat	19°
,, Clark's cell	18°
Weight of silver cup after deposition	26·1963 gms.
,, ,, before ,,	26·1453 ,,
Silver deposited in 10 min	0·051 ,,
,, ,, 1 min	5·1 mgs.

$5{\cdot}1 \times 20 = 102 = e.$ $\qquad 102 \div 71{\cdot}105 = 1{\cdot}434 = E.$

The electromotive force of a Clark element is therefore 1·434 volts, the exact value given by Lord Rayleigh* instead of the formerly accepted value of 1·457 volts.

The mean of all the values of the electromotive force in the last column of the table is 1·122, which is the value obtained by Sir William Thomson by the electrostatic method, if the velocity expressing the ratio between the electrostatic and electro-magnetic units be taken as 3×10^{10}.

In Fig. 2 the results of the investigation are set forth graphically; the ordinates represent the excess of the quantities in Column 7 of the table above 74, the value obtained with distilled water; while the corresponding abscissæ denote percentages of zinc sulphate. It will be observed that little variation in the value of the electromotive force occurs after reaching ten per cent. of zinc sulphate, and that the maximum value appears to be at about five per cent. I have some reasons for doubting the accuracy of the larger of the two values found with the five per cent. solution. If the smaller value alone is employed the points laid off may be connected by nearly a plane curve.

It thus appears that the variation in the concentration of the zinc sulphate solution is sufficient to account for the larger part of the discrepancy between the results obtained by different experimenters in measuring the electromotive force of a Daniell cell. It would therefore seem desirable that a standard Daniell element should be so constructed as to admit of employing a zinc sulphate solution of known concentration. The form proposed by Prof. G. F. Barker,† in which the solutions are satuarated, appears to meet the requirements in this respect.

North Western University, Evanston, Ill., August, 1884.

* *Nature*, March 20, 1884, p. 495.

* *Nature*, March 20, 1884, p. 495. In his Montreal Presidential address Lord Rayleigh gave the value 1·435 volts.

† *Proc.* Amer. Philos. Soc., Jan. 19, 1883, p. 654.

CITY AND GUILDS OF LONDON INSTITUTE.

TECHNOLOGICAL EXAMINATIONS, 1885.—EXAMINER, PROF. W. E. AYRTON, F.R.S.

22B. Electric Lighting and Transmission of Power.

INSTRUCTIONS.—This examination is for the purpose of ascertaining whether the candidate has intelligently studied the methods of constructing and using the machinery employed in the production and transmission of electric power, and whether he has endeavoured to ascertain the scientific reasons underlying the processes adopted. The candidate must confine himself to one grade only, the Ordinary or Honours, and must state at the top of his paper of answers the grade he has selected. He must not answer questions in more than one grade. If he has already passed in this subject, in the first class of the Ordinary Grade, he must select his questions from those of the Honours Grade. The number of the question must be placed before the answer in the worked paper. Three hours allowed for this paper.

ORDINARY GRADE.—[Candidates are not to answer more than two out of the first three questions, and not more than seven questions altogether.]

1. Explain exactly what is meant by saying the electric resistance of a given wire is constant for the same temperature, and independent of the current passing through the wire.

2. A battery is sending a current through a wire. If this wire be gradually made shorter and shorter, describe what changes will take place (1) in the current, (2) in the potential difference at the terminals of the battery, and (3) in its electromotive force.

3. Define fully an ampere, an ohm, and a volt. What current will 15 cells, each having an E.M.F. of 1·07 volt and an internal resistance of 0·7 ohm, send through an electro-magnet having 28 ohms resistance, when the electro-magnet is shunted with a wire having 7 ohms resistance?

4. Why is it necessarily more costly to produce a given amount of light with incandescent lamps, as at present made, than with arc lamps?

5. Describe, with detailed sketches, some form of arc lamp with apparatus for automatically maintaining a fixed length of the arc.

6. What is meant by a compound wound dynamo? Describe, with detailed sketches, some form of compound wound dynamo.

7. Describe, with sketches, some form of commercial instrument for measuring strong currents, and mention what conditions ought to be fulfilled by such an instrument.

8. Edison glow lamps requiring 108 volts potential difference, and 0·72 of an ampere each, are required to be fed by accumulators, each having 2·1 volts E.M.F., and 0·0017 ohm resistance. What is the least number of such accumulators arranged in series that must be employed to feed 200 of these lamps in parallel?

9. Explain, with sketches, the instruments as well as their arrangements that you would employ to measure the "efficiency" of an arc lamp. Give examples of the sort of result you would expect to obtain.

10. Why cannot the direction of rotation of an electric motor be reversed by reversing the direction of the current passing through it? Describe, in detail, the methods by means of which the direction of rotation may be reversed.

11. Why are low resistance galvanometers used to measure large currents, whereas high resistance galvanometers are employed to measure large differences of potential? If a high resistance galvanometer arranged to measure the difference of potential between two points A and B in an electric circuit were replaced with a low resistance galvanometer, but without any other change being made in the arrangement, what would now be measured by this low resistance galvanometer?

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12. What is meant by the "lead" in the brushes of a dynamo? Explain fully why sparking at the brushes occurs if the lead is wrong.

13. The potential difference at the terminals of a series dynamo running at a constant speed first increases, and then diminishes, if the external resistance be first large and then be steadily diminished. Give an explanation of this, graphically if you can, employing the characteristic curve of the dynamo.

14. Describe, by means of detailed sketches, the mode of constructing and connecting up (1) a separately excited, (2) a series, (3) a shunt dynamo.

15. What is a "watt?" Give a drawing and description of a watt meter.

HONOURS GRADE.—[Candidates are not to answer more than one out of the first three questions, and not more than seven altogether.]

1. Explain exactly what is meant by saying that the electric resistance of a given wire is constant for the same temperature and independent of the current passing through the wire.

2. A battery is sending a current through a wire. If this wire be gradually made shorter and shorter, describe what changes will take place (1) in the current, (2) in the potential difference at the terminals of the battery, and (3) in its electromotive force.

3. Define fully an ampere, an ohm, and a volt. What current will 15 cells, each having an E.M.F. of 1·07 volt and an internal resistance of 0·7 ohm, send through an electro-magnet having 28 ohms resistance, when the electro-magnet is shunted with a wire having 7 ohms resistance?

4. Describe, with sketches, the mode of constructing and connecting up the wires in an alternate current motor.

5. How should two alternate current generators be coupled up so that the currents produced by the two generators may assist one another? Explain fully why the method you describe fulfils its object.

6. What sort of error would be produced by using a high resistance galvanometer to measure an alternating difference of potential? In what way can an alternating potential difference be measured accurately?

7. It is found that with a magneto-electric machine the E.M.F. is not absolutely constant for a given speed, but varies with the current produced. Why is this, and how can this variation of E.M.F. be reduced to a minimum?

8. What are the advantages and disadvantages of using secondary batteries? Show how a secondary battery should be attached to an electric light circuit fed with a shunt dynamo in order to steady the light.

9. In the last question calculate what may be the greatest resistance of a secondary battery compared with the resistance of the other portions of the circuit, so that the potential difference at the terminals of the lamp circuit shall not vary by more than 1 per cent. when the E.M.F. of the dynamo increases by 8 per cent.

10. Judging from the experiments and calculations that have been hitherto made, in what cases would you recommend the employment of water transmission, and in what cases electric transmission of power?

11. What are the exact experiments that should be made with an incandescent lamp in order to determine its commercial value relatively to that of other incandescent lamps?

12. You are required to design and fit an electro-motor to a tramcar. Describe the advantages and disadvantages of the following three methods:—(1) A rapidly-turning motor attached to the ordinary tramcar wheels with some speed-reducing gear, (2) a rapidly-turning motor attached to a small driving wheel running on the rail without speed-reducing gear, (3) a motor attached directly to the ordinary tramcar wheels, and only turning as fast as they ordinarily do. Select the one of the methods that you consider the best, and give sketches of the exact way in which you would carry it out.

13. Give detailed drawings of a non-sparking key.

14. Draw a curve connecting potential difference at the terminals of a shunt dynamo with the current flowing in the external circuit, and show how you can graphically construct from this a curve connecting the total electromotive force in the dynamo with the total current flowing through the armature.

15. What are the advantages and what the disadvantages of feeding the incandescent lamps in a district in series?

16. Show why the Board of Trade regulation requiring electric light to be supplied to a house within a given distance of the mains, and which must be charged for a fixed rate per Board of Trade unit, and, independently of the time per night that the current is required, cannot work fairly both in the interests of the supplier and consumer.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

The meeting of this society on Thursday, 28th May, Mr. Spagnioletti, the president, in the chair, was occupied with two papers relating to certain recent installations of electric lighting. The one by Mr. B. J. FARQUHARSON, member, set forth the results of the experimental trial on board H.M.S. "Colossus;" the other, a descriptive account of the lighting of the works for the construction of the new Forth Bridge, was by Mr. JAMES N. SHOOLBRED, B.A., member. Mr. Farquharson, explained that the fitting up of the "Colossus" with incandescent lamps was by order of the Admiralty for the purposes of ascertaining the expense of this mode of lighting compared with that of the oil lamps ordinarily employed in H.M. Navy. There was nothing novel in the arrangements, but the results were highly satisfactory and encouraging for this class of electric lighting enterprise. Full details were given of the distribution of the lamps (400 in number) over the various parts of the ship, and the hours during which the several groups were kept burning—some day and night continuously, others for a few hours each evening. The trial extended over seven consecutive days and nights, a period considered sufficiently long to determine the question to be decided. The balance of saving proved to be at the rate of £1,852. 14s. 8d. per annum compared with the cost of maintaining oil lamps, which latter of course included the charge for lamp trimmers, &c. In this and other respects the trial had given such satisfaction to the Lords of the Admiralty that their lordships had just issued an order for the fitting-up of all the great war ships in a similar manner with electric lamps. Detailed and tabulated summaries of the seven days' steaming of electric engines, and the average readings of the dynamos were furnished with Mr. Farquharson's paper, but they presented no features of exceptional or novel character.

Mr. SHOOLBRED'S paper described very carefully the important installation at the Forth Bridge works, which began in 1883 and are still in progress. The bridge has a total length of about a mile and a half, and the works on land where the materials of the bridge are constructed before being placed in position extend over another half mile or more. The special peculiarities of the installation are that much of the lighting has to move with the constantly shifting work, and that a great deal of the work is done under water. Both arc and incandescent lamps are employed, sometimes running as long as 700 hours at a stretch. It was also necessary to give confidence to the workmen employed, so that no fears need be apprehended of accident from touching the wires. 120 volts is, therefore, the maximum power used. Messrs. Siemens have the south side of the bridge under their care, the north portion being lighted by Messrs. Crompton. They have got through the severities of two winters without any hitch or accident, and the efficiency of the lighting has been warmly acknowledged. Some of the lights were a mile and a half distant from the engines; yet, on the whole, the losses by distribution are less than the generally accepted average, especially in the work sheds, where the temperature is highly favourable to economic supply. Owing to the sea spray which fills the air in the neighbourhood of the bridge, the relative durability of india rubber and gutta percha as insulators had been tested under these conditions, and it was found that the former very soon became useless, solid gutta percha being better; but naked copper wires are frequently used, and the corrosion is found to be very slight. As to the duration of the Swan lamps employed in this installation, the average for the first half year was 404 hours, for the year following it rose to 700, whilst for the present half year not yet expired—during which the latest improved form of lamps has been introduced as the older ones gave in—the average life is 1,200 hours.

The discussion which followed was confined chiefly to the lighting of the "Colossus." Mr. CROMPTON pointed out that the conditions of all such trials are highly unfavourable in one respect, seeing that low pressure steam is the rule on board H.M. steamships, the least economical power for electric lighting. Mr. ALEX. SIEMENS also pointed out that the loss of lamps in this experiment (no less than 60) was altogether unprecedented. Probably a bad lot of lamps had been supplied to the undertakers. At the Savoy Theatre there were quite a large number of lamps which had been burning from the very first; and a P. and O. boat making the journey to and from New Zealand had returned with only one breakage. The secret of prolonging the life of these lamps was to always run them well below their power of endurance. Professor Ayrton, Dr. Fleming, and Mr. Swinburne also took part in the discussion.

THE ERRORS IN INDICATOR DIAGRAMS.

At the ordinary meeting of the Institution of Civil Engineers, on the 19th ult., a paper was read "On the Theory of the Indicator and the Errors in Indicator Diagrams," by Professor O. Reynolds, M.A., LL.D., F.R.S., M. Inst. C.E.

The object of the paper was to define the causes and extent of the disturbances in indicator diagrams. The theory, as given, had been taught for several years in Owens College; but the publication had been deferred to enable an extensive series of experiments to be made. These experiments had now been carried out by Mr. A. W. Brightmore, Stud. Inst. C.E., late Berkeley Fellow in Owens College. In the first place it was shown that there were five principal causes of disturbance, namely, the inertia of the piston of the indicator and its attached weights; the friction of the pencil on the paper, and its attached mechanism; varying action of the spring; inertia of the drum; friction of the drum.

The effect of the inertia of the pencil and its attached mechanism presented a mathematical problem, by the solution of which it was shown that there were two disturbances from this cause; one, a general enlargement of the mean indicated pressure, depending on the weight of the moving parts of the indicator, the stiffness of the spring, and the square of the speed. The other disturbance was a vibration of the pencil. Every indicator piston vibrated when disturbed, so that the period of vibration depended on the stiffness of the spring.

The error which these oscillations caused in the area of the diagram depended on their magnitude, and, to a greater extent, on the smallness of the number in a revolution. But the evil of these oscillations was not so much an effect on the area as in the disfigurement and the confusion they produced in the diagram. So long as there were 30 of these oscillations in a cycle, the necessary fluid friction of the indicator piston would so far reduce them as to render a fair diagram possible, but when the number was as low as 10 it was all the pencil could do to prevent them upsetting the diagram.

The friction arising from the pressure of the pencil always acted to oppose the motion of the pencil, and therefore rendered it too large during expansion and exhaust, and too small during compression and admission, and thus the general effect was to increase the size of the diagram. This

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friction consisted of that of the pencil on the paper ; and that of the mechanism, caused by sustaining the pressure of the pencil. The effect of the friction of the pencil was greatly reduced by the motion of the paper. The magnitude of these effects taken together on the area of the diagram depended on the construction of the instrument and on pencil-pressure. From numerous experiments it would appear possible to make a difference of as much as 5 per cent. in a locomotive in mid-gear by pencil-friction.

The conclusions, as regarded the motion of the pencil, were that the general effect of inertia and friction were both to increase the size of the diagram ; that so long as the speeds were such that the number of vibrations of the pencil during a revolution of the engine was not greater than 15, the effect of inertia was less than 1 per cent., but that if the number was greater than 30, oscillations would show themselves unless the pencil-friction was increased. They might by this be kept down till the number of vibrations was equal to 15, but not farther, and then the necessary friction would affect the area of the diagram about 5 per cent. For the diagrams to be sensibly accurate and free from oscillation the speeds must not be greater than would make the number of vibrations equal to 30. These speeds were given in the paper for Richards' indicators.

The effect of the inertia of the drum with an elastic cord was shown to be a nearly uniform elongation of the diagram. The result of the varying stiffness of the drum spring was a nearly uniform contraction. With Richards' indicator these two latter disturbances neutralised each other at a speed of 150 revolutions per minute. At other speeds the effects were apparent in the length of the diagram ; but except when the expansion was great and the connecting rod short, they did not affect the indicated pressure. The friction of the drum with an elastic cord caused the cord to be longer during the forward stroke than during the backward stroke, so that the diagram was distorted and shortened, the drum being uniformly behind its proper position during the forward stroke, and before its position during the backward stroke. This distortion diminished the area of the diagram according to the rate of expansion and the length and elasticity of the cord used. This was definitely expressed by a formula. This disturbance, the influence of which was very great in cases of high expansion, large engines, and ordinary cords, appeared to have been unnoticed. The circumstances on which it depended were the elasticity of the cord and the friction of the drum, and the question was how far these existed in the ordinary indicators. It might be said that the diagrams which led to the discovery of this effect were taken with an indicator which had been in constant use for several years. It was in apparently perfect condition, and the diagrams did not differ essentially from those which had been previously taken. The cord was one which had been supplied by the maker. The manner of the discovery was described :—For years the author had pursued in the class the method of testing the vibrations of the indicator pencil by projecting them on the crank-circle, and he had noticed that the first oscillation fell short, and shorter in the back diagram than in the front. The cause of this was not obvious, and it was partly with a view to determine this cause that Mr. Brightmore's investigation was commenced. A slight error in the reducing rod, which had a fixed centre and a slot in which a stud in the slide block worked, was altered. This, however, did not get rid of the effect. A new cord was substituted for the old one, and the effect was found to be much enhanced, the new cord being more elastic than the old one. This reduced it to the stretching of the cord, but it was only after carefully working out the effect of the inertia of the drum, and it was seen this was to lengthen the first oscillation at the back end that the friction was examined. The indicator was taken to pieces, cleaned and oiled ; then the effect was much reduced. Several new wires and cords were used, and eventually steel wire was adopted as the best. The test supplied by the oscillations could only be applied to diagrams taken at high speeds, and the test furnished by the influence upon area was vague. What was wanted was an independent means of determining the simultaneous positions of the drum and the engine piston. As the best method of meeting this, it was decided to arrange an electric circuit through the pencil to the drum, with sufficient electromotive force to prick the paper, making the engine piston close this circuit at eleven definite equidistant points in the motion backwards and forwards. This was successfully carried out, and the stretching of the cord during the backward and forward strokes was definitely ascertained. Taking the smallest results obtained with a cord, it appeared from these experiments that the least difference of stretching was to make this difference in inches 5 per cent. of the length of the cord in feet. Examples of this effect in diminishing the mean indicated pressure were given. Thus, in a locomotive cutting off at one quarter it was 8 per cent. ; in a condensing engine having 3·5ft. stroke, cutting off at one-tenth, 20 per cent. ; and the same compounded, 10 per cent.

These would seem to be the smallest results that could have occurred in ordinary practice. The conclusion, however, that hitherto the normal indicated power from engines had been from 10 to 20 per cent. too small must wait for verification. Yet there were not wanting independent evidences of such an effect. In diagrams taken from engines at high speeds the admission line would not but for this effect be vertical. It would show a certain amount of detail, and the first oscillation would not have a sharp top. Moreover, it was commonly found that the expansion line, allowing for clearance, was above the true expansion line for the steam. This apparent rise in the curve of expansion was exactly what would result if the apparent cut-off was too early, and this was the result of the effect that had been considered. The author has tried several diagrams, and found that after correction the expansion line came out very close to the true curve.

In making these comparisons the explanation of another feature of diagrams became apparent. When the two diagrams were traced on the same card there was sometimes a want of symmetry about them, and in this case the cut-off was shorter on the back than on the front diagram. This the author attributed to the friction of the drum when the cord for the back diagram was longer than that for the front. When this was the case the relative lengths of the cord were about 1 to 1·8. These observations were illustrated in a diagram from Richards' indicator. To test this diagram a tracing was taken, and reversed so that the front diagram was superimposed on the back. It was observed that the diagrams were of different lengths, and the difference was about the same as the difference in cut-off ; that notwithstanding the apparent cut-off in the back diagram was to that in the front in the ratio of 2 to 3, the expansion line of the back diagram was the same shape as that in the front ; and that if the diagrams were restored, supposing the lengths of the cords used to have been 5ft. and 9ft., the diagrams became exactly similar, and, allowing 2 per cent. clearance, the expansion line came to be the true expansion line for that cut-off. The mean pressure was 14 per cent. larger than from the original diagram.

Such instances as these seemed to sufficiently establish a case against the blind faith which appeared to be at present placed in the accuracy of the indicator diagrams. But in conclusion, the author stated that he should be very disappointed if anything in this investigation should have the effect of diminishing reliance on the indicator itself. He would have the instrument treated fairly, and instead of being the object of unthinking worship he would have it the object of careful study and experimental investigation, so that the limits of its wonderful perfection might be known exactly, and that reliance placed on it which sprang from knowledge.

BUSINESS NOTICE.—We are requested to announce that the Bernstein Electric Lamp Company have removed their offices to and have commenced manufacturing at 9A, Commercial-road, Pimlico, S.W.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JUNE 3.		BUSINESS DONE WEEK ENDING JUNE 3. Highest.		Lowest.
Anglo-American	28½,	29½	28¾		28¾
Do. Preferred	48½,	49½	49		48¾
Do. Deferred	7½,	8½	8⅝		7⅛
Brazilian Submarine	11½,	11¾	11 7-16		11
Cuba	11,	11½	11⅝		11¼
Do. Preference	17½,	18½	—		—
Direct Spanish	1½,	2	1½		—
Do. Preference	11½,	12½	12		11½
Direct United States Cable	8½,	9½	9½		8¾
Eastern Telegraph	11¾,	12	11 15-16		11½
Do. 6 per Cent. Preference	13½,	14	14		13½
Do. 5 per Cent. Debentures, 1899	104,	107	106½		—
Eastern Extension	12⅜,	13	12 15-16		12⅜
German Union	9½,	9¾	—		—
Globe Telegraph and Trust	7,	7½	7⅛		6 15-16
Do. Preference	12⅜,	13½	13½		12¾
Great Northern	14,	14½	14½		13¾
Indo-European	30½,	31½	31		—
Reuter's	7½,	8	7 9-16		—
Submarine	180,	190	—		—
West India and Panama	⅜,	1	⅜		⅜
Do. 1st Preference	7⅜,	8½	7⅞		7½*
Western Brazilian	6,	6½	6⅜		5 15-16
Western Union 7 per Cent. 1st Mortgage	117,	122	—		—
Do. 6 per Cent. Sterling Bonds	100,	103	—		—

* x.d. 6s. on account of arrears.

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	⅝	—		—
Oriental	⅛,	⅜	—		—
United Telephone	11¾,	12½	12½		11¾

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	1¾		—
Do. (fully paid)	3½,	4	3¾		3½
Hammond Light (£3 15s. paid)	¼,	½	5-16		—
Swan	¼,	½	—		—
Maxim-Weston	⅛,	¼	—		—

MISCELLANEOUS.

Telegraph Construction	35½,	36½	36¾		35¾
India Rubber, Gutta Percha, and Telegraph Works	24,	25	24½		22½

TRAFFIC RECEIPTS FOR MAY, 1885.

COMPANIES.	May, 1885.	May, 1884.	Increase.	Decrease.
Brazilian Submarine	—	—	—	—
Cuba Submarine	3,700	2,973	727	—
Direct Spanish Telegraph	1,345	1,552	—	207
Direct United States	—	—	—	—
Eastern Extension	50,016	41,708	8,308	—
Eastern Telegraph	61,327	51,537	9,790	—
Great Northern	—	—	—	—
Submarine	—	—	—	—
West Coast of America	—	—	—	—
Western and Brazilian	—	—	—	—

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NOTES.

NEW LARYNGOSCOPE.—A new electric laryngoscope has recently been invented by M. Curt W. Meyer, of New York.

THE ELECTRIC LIGHT IN MILAN.—According to *Il Giorno*, electric lighting experiments are about to be carried out in the Piazzo de Duomo, Milan.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 5th inst. amounted to £3,009.

THE EASTERN TELEGRAPH COMPANY'S CABLES.—Both the cables between Aden and Bombay are interrupted, but advices of repair are, however, hourly expected.

THE WESTERN UNION TELEGRAPH COMPANY.—A Reuter's telegram from New York states that this company has declared a dividend of 1½ per cent. for the past quarter.

CABLES IN NEW YORK HARBOUR.—On May 24 the fifth armoured cable of the Baltimore and Ohio Telegraph Company was laid across the Narrows, New York Harbour.

THE TELEGRAPH IN SIAM.—Four operators have contracted to go to Siam to introduce the Morse system of telegraphy in that country. They left San Francisco on the 1st inst.

ELECTRIC LAUNCH.—A successful trial of a new electric launch has recently been made upon Lake Maggiore, at Meina, by the Societá Industriale Franco-Italiana, of Milan.

SECONDARY BATTERIES.—We have received an excellent little treatise, being a selected paper from the *Proceedings* of the Institution of Civil Engineers upon the subject of Secondary Batteries, by Mr. Frank Geere Howard.

THE GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this company are as follow:—Receipts for May, £28,800; 1st January to 31st May, £118,000; corresponding months, 1884, £106,560; 1883, £100,360.

THE TELEPHONE IN PARIS.—Considerable agitation is going on in Paris for a reduction of the telephone tariff. A league of 88 subscribers has been formed at No. 9, Rue des Vosges, and by all accounts the object is not unlikely to be attained.

THE ELECTRIC LIGHT IN BROOKLYN, U.S.A.—The opening day of the Williamsburgh Athletic Club, Brooklyn, was marked by the attendance of 7,000 persons at the games, which were continued through the evening with the aid of the electric light.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 5th inst., were £2,402, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

CITY AND GUILDS OF LONDON INSTITUTE.—The summer course of lectures and laboratory instruction will commence in the institute's new buildings, in Exhibition-road, on Monday, 22nd June. Full particulars will be found in our advertisement columns.

THE SUBMARINE CABLES BILL.—The minutes of the House of Lords record that, among others, this Bill has been "read and discharged." This, however, does not mean that the Bill has been abandoned, but merely that no day has been fixed for taking the stage at which it stands.

CHAIR OF EXPERIMENTAL PHYSICS.—Particulars will be found in our advertisement columns of an invitation issued by the Council of the University College, Bristol, for applications for the Chair of Experimental Physics in that College, and also for the post of Demonstrator.

GILDING REFINED GOLD.—At a dance given last week in the Cromwell-road the hostess's daughter wore a pink rose in a spray lighted by a small lamp inside, the current being supplied by a Woodhouse and Rawson small portable accumulator carried in the dress. The effect was very charming.

CRYSTAL PALACE PARK ILLUMINATIONS.—A new feature in the illumination of the grounds is the employment of many large arc lamps, which shed electric light on the walks and terraces from elevations carefully studied to avoid interference with the effect of the multitude of smaller lights near the ground.

COMPLETION OF A NEW CABLE.—The Faraday, cable-laying steamship, arrived off Penzance on Wednesday evening. She has been engaged in the work of laying a new cable between Waterville and Weston-super-Mare. The final splice making the communication complete was effected on Wednesday morning.

THE ENGINEERS' CAMP NEAR ST. PETERSBURG.—A telegram from St. Petersburg announces that at the Engineers' Camp near St. Petersburg, detachments of infantry and cavalry will this summer be instructed in the work of the sappers and miners, including the construction and destruction of telegraphs and railways.

THE EXPLOSION ON THE "INFLEXIBLE."—The Admiralty have already provided against such accidents as that which has recently occurred by deciding to adopt the electric light even in the coal bunkers. Some of the fittings now being supplied by Messrs. Goolden and Trotter are strong hand lamps specially designed for use in the bunkers.

THE ELECTRIC LIGHT AT MORLEY.—Messrs. Hudson, Sykes, and Bousfield, woollen manufacturers, Springfield Mills, Morley, have introduced about 400 incandescent lamps into their weaving sheds. A trial which was recently made of the experiment proved very successful, and the electric light for the purposes of illuminating large rooms was demonstrated in a most striking manner.

THE TELEGRAPH TO MERV.—A Reuter's telegram dated Simla, 6th June, says:—"The Russian telegraph line has been completed to Merv, and will be further extended to Mahna, seventy miles from Sarakhs." Mahna is in all probability the Mehna of the maps, and if this is the case it would seem that the line has been extended to Merv across the Tjend, and will branch off at Mehna to Sarakhs.

THE SS. "DACIA."—The ss. "Dacia," belonging to the India Rubber, Gutta Percha, and Telegraph Works Company, arrived in the Thames on the 7th inst., after having completed the repair of the old Havanna-Key West cable. About forty knots of new cable have been introduced to replace the same amount, which was picked up and stored on shore for future use in repairs should necessity arise.

DOMESTIC LIGHTING.—Messrs. Verity and Sons, of Covent-garden, have recently put down an installation of over 230 lamps for Chas. Combe, Esq., at Cobham Park, Surrey. The experiments have so far resulted in a most pronounced success. The same firm are at present lighting up Errol Park, Scotland, for Ogilvie Dalgleish, Esq., with 170 lights, and have obtained the contract for a similar installation in the south of England. We wish them every success.

TEMPORARY LIGHTING.—At a dinner party given at 69, Portland-place on the 2nd inst. the rooms were lit by incandescent lamps. The work was carried out for Messrs. W. Hucks and Co. by the Electrical Power Storage Company. At a ball given after a wedding at St. Ronan's, Tulse Hill, S.W., on the 11th inst., the rooms and conservatories were lit through-

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out by incandescent lamps. The work was carried out by the Electrical Power Storage Company.

THE DEFENCE OF PORT CHALMERS.—Mr. W. Prince, electrician to the Union Steamship Co. and also to R. E. Fletcher and Co., of Dunedin, has been appointed by the Defence Minister to take charge of the proposed submarine torpedo arrangements at Port Chalmers. Mr. Prince brought with him from Wellington instructions for carrying out the scheme, and he will be furnished with the necessary assistance in the shape of men and material by the Public Works Department.

THE NEW ZEALAND TELEGRAPHS.—The Wellington quarterly return shows that the telegraphic revenue for the past quarter was as follows :—

Messages.	Number.	Value.
Total for the Colony	401,412	...£26,776
Corresponding quarter 1884...	362,405	... 23,407
Government telegrams	62,051	... £6,606
Corresponding quarter 1884...	58,036	... 5,543

THE UNITED TELEPHONE COMPANY.—The directors of this company, at their meeting held on the 10th inst., decided, subject to audit and after making provision for depreciation, &c., to recommend at the forthcoming general meeting a dividend for the half year ended 30th April last at the rate of 7s. 6d. per fully-paid share, part-paid shares receiving in proportion, making, with the interim dividend on 2nd December last, a total distribution for the twelve months ended 30th April last of 10 per cent. per annum, carrying forward a substantial sum to reserve.

ELECTRIC LIGHT FOR INTERNAL NAVIGATION.—At the International Congress of Internal Navigation, held last week at Brussels, M. de Saint-Hubert, in describing his project for a uniform system of water ways connecting the principal cities of Europe, referred to the use that might be made of the fall of water over the weirs in canalised rivers for driving turbines connected directly with dynamo machines. The current thus generated would serve to maintain arc lights for illuminating, not only the locks and their approaches, but also the shores, so that navigation might be continued by night as well as by day.

THE ROYAL SOCIETY.—On Wednesday evening a *conversazione* given by the Royal Society took place at Burlington House. Among those present were Prince Bonaparte, Lord Bramwell, Sir J. Lubbock, M.P., Sir F. Bramwell, Sir James Paget, Sir A. Hobhouse, Prof. Ray Lankester, and many other gentlemen distinguished in science and art. The guests were received by Prof. Huxley, the president of the society, and many objects, scientific and mechanical, were displayed, including a number of Edison incandescent lamps, exhibiting molecular shadows and transparent deposit of copper, and other kinds of electrical apparatus.

THE HAMMOND ELECTRIC LIGHT AND POWER SUPPLY COMPANY.—A petition for winding up this company has been presented to the High Court of Justice by Mr. Robert Hammond, who is described as a "merchant, a creditor, and contributory" of the company. The petition is directed to be heard by Mr. Justice Kay, on the 20th inst. Provision will probably be made for carrying out contracts that have been entered into by the company to light, among other places, the Mansion House, the Grand Theatre at Islington, the Brighton Aquarium, and the Prince of Wales Theatre, Birmingham, and an order has been made authorising the liquidator to pay wages not exceeding £200 a week, subject to proper security being provided.

PROJECTED ELECTRIC LIGHTING OF A TOWN IN NORWAY.—We understand that the town of Bergen in Norway is to be lighted by electricity. A company is being formed to start a central station, and already promises have been received to take 3,000 incandescent lights and 70 arc lamps. The price of gas is 6s. 6d. per 1,000, and the price of coal from 11s. to 12s. per ton delivered at the central station. The engineer, Mr. J. S. Hopstock, is now in London for the purpose of getting tenders from the leading English firms, and it is hoped that the installation will be at work before Christmas this year. The company expects to pay from 5 to 6 per cent. to the shareholders, and obtain the sole concession of the town council for a number of years.

THE SIXPENNY TELEGRAMS BILL.—Nothing is certainly known yet as to the fate of this Bill, although there were confident statements yesterday that it would be abandoned—at all events in its present form. This conjecture is based simply on the fact that Lord John Manners, the past and probably future Conservative Postmaster-general, disapproves of the abolition of free addresses. If a Conservative Ministry come into office it will be difficult, therefore, for them to press the Bill forward in its present shape. On the other hand, all the departmental arrangements and calculations are based on the halfpenny a word rate all round, including the addresses; and it will be next to impossible to reconstruct the Bill at the last moment on a different basis. But the Conservatives have not yet taken office; and nothing can be safely predicted as to the Bill until they do.

NEW ELECTRIC RAILWAY.—According to an American contemporary, a new electric railway, the invention of Professor Short, of the Denver University, has recently been given a practical test. The inventor claims for this invention that it possesses principles not used in the Edison and similar inventions. The test was made over 300 feet of track built in a semi-circle and having at one point a grade of 250ft. to the mile. The track was a few inches narrower than that of a narrow-gauge railway. The dummy car built for the occasion contained five persons, and was propelled over the track at a lively rate of speed. Some time ago a company was formed to build a cable-car line in Denver, on which this invention is to be used, and already tracks are laid upon a number of the streets.

THE NAVAL AND MILITARY CLUB INSTALLATION.—We are informed that the contract for this installation has been obtained by Messrs. B. Verity and Sons, of King-street, Covent Garden. The plant is to consist of two double cylinder engines and boilers, two Edison dynamos of the latest form, and a large set of fifty-five Elwell and Parker accumulators. The engine room will be specially constructed at the back of the club, and throughout the whole installation every attention will be paid, and no expense spared to make this one of the most successful examples of electric lighting. This club will, no doubt, add to its already great and deserved popularity by being the first in London to enlist so necessary an adjunct to comfort in its service. We may mention that there were five tenders sent in for this work. The plant is to be completed and in operation by the end of August.

HEARING THE EARTH'S MAGNETIC INDUCTION.—Dr. Schaper recently demonstrated to an audience the magnetic induction exercised by the earth. A number of telephones were arranged in series upon one circuit, which was rapidly made and broken by an interrupter. A telephone was then repeatedly turned end for end in such a way that its north and south poles were alternately the uppermost, and at each reversal a crack was heard in all the telephones, resulting from the induction of the

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earth on the central magnet. If the experiment be made with an induction bobbin only the crack is extremely feeble, due in that case to the induction of the earth on the bobbin. The telephone may be replaced by a magnet wrapped with insulated wire. The degree of sensibility of the telephones can be determined if the axis of rotation of the magnet employed in the experiment be brought little by little nearer to that of the inclining apparatus.—*Scientific American.*

CAUSE OF EARTHQUAKES.—Our contemporary, the *St. James's Gazette*, says that M. Perey, a Dijon astronomer, offers a novel explanation of the frequency of the earthquakes which have produced so much disturbance on the surface of our planet of late. His theory is that they are caused, like the tides, by the attraction of the sun and moon; and he argues that it is only natural to suppose that the sea of fire in the interior of the globe obeys the same influences as the ocean on its surface. M. Perey has investigated the particulars of no fewer than 5,400 different shocks of earthquake; and a comparison of their dates demonstrates that these phenomena are most frequent during the periods of full and new moon. He has further ascertained that the shocks have been most violent when the moon has been in the meridian of the place where they occurred, just as the tide in a seaport over whose meridian the moon is passing is higher than that in any of the neighbouring ports.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The general meeting of the American Institute of Electrical Engineers was held on 20th May, at the house of the American Society of Civil Engineers, at 127, East Twenty-third-street. The first paper was on "The Protection of Inventions," by Mr. Frankland Jannus, of Washington. In the course of the discussion which followed it was stated that there was no chemical or electrical laboratory in the Patent Office. A resolution to the effect that a committee be appointed to call the attention of Congress to the needs of the Patent Office, especially in regard to the class of electricity, was referred to the council for action. A paper on "The Cost of Mine Lighting," by Mr. F. P. Mills, was read by the secretary. Mr. Edward P. Thompson read a paper on "The Electric Arc Lamp Frictional Clutch," and described at length a clutch in the shape of a spiral spring, the use of which he claimed would produce good results in the way of steadiness of light and regularity of feeding the carbon.

THE EARTHQUAKE IN CASHMERE.—Further particulars are given of the severe earthquake which occurred recently in Cashmere. The barracks at Serinagur were destroyed, about 100 men and 150 horses being buried in the ruins. Forty-six men were killed, and 50 were seriously hurt. Forty-one lives were lost in the city, and many persons were injured. The Maharajah's palace was partly destroyed, and the British residency was greatly damaged. Many villages were wrecked, and much damage was done throughout the valley. A mosque at Sopar fell, burying 200 persons. No Europeans are reported to have been killed. It is stated that the shocks continued all the next day. A Reuter's telegram from Simla, 6th June, announces that the British Resident in Cashmere reports that shocks of earthquake continue to be felt in that province. In several places the earth opened and swallowed up houses, while hot water and clouds of sulphurous dust were ejected from the chasms. These phenomena were accompanied by loud subterranean rumbling. Generally speaking the movement of the earth has been comparatively slight.

OVERHEAD WIRES.—According to the *Pall Mall Gazette* the United Telephone Company have determined not to proceed with their Bill dealing with the erection of overhead wires. The Bill provided that the company might erect and maintain wires over any land or road, provided that by so doing they should not be deemed to acquire any right other than that of user only in the soil. Provision was made that the company should do as little damage as possible, and should make full compensation (the amount to be determined in case of dispute by the Local Government Board) for any damage caused by the exercise of their powers. The powers of the company were to be subject to the restriction that they should not erect posts upon or lay wires under any property without the consent of the occupier; and special restrictions were imposed with regard to interference with public roads. The Press Association learns that the Government do not intend to follow up the recent report of the Select Committee on Overhead Wires by any legislation, considering that the recommendations passed by the majority of the committee were impracticable, and would invade private rights to an extent for which the Government cannot make themselves responsible.

HONOURS FOR TELEGRAPHISTS.—In connection with the festivities incident upon the celebration of Her Majesty's birthday, the honour of knighthood has been conferred upon Mr. Henry C. Mance, the inventor of the heliograph and of several methods of electrical testing which will doubtless be well known to many of our readers. Mr. F. E. Baines, one of the assistant secretaries of the General Post Office and Inspector-General of Mails, has, in recognition of his many valuable services in connection with his department, received the well-merited distinction of the Civil Companionship of the Bath. Mr. Baines was for many years in the service of the Electric and International Telegraph Company; during that time he formulated a scheme for the transference of the telegraphs to the Government, which, we have every reason to believe, led to the adoption of the present system. He was then, or shortly after the transfer took place, appointed to the post of Surveyor-General of Telegraphs, a position in which he remained until the project of establishing an efficient parcels post engaged his attention. Mr. Baines ultimately received the appointment of Assistant-Secretary to the Post Office and Inspector-General of Mails, in order that he might be better able to devote himself more particularly to the departmental arrangements and alterations which that scheme entailed.

EDISON'S LATEST INVENTION.—Mr. Edison's latest invention, an arrangement to telegraph from moving trains, is thus described by a recent visitor to his laboratory:—Overhead was a board eight inches wide, suspended from the ceiling by ropes fastened to one of its edges. One side of it was covered with tin foil and was facing toward a wall twenty feet distant. "That," said Mr. Edison, "is my railroad signal; I make electricity jump 35ft., and carry a message. This is something quite new, no induction has ever been known that extended over three or four or five feet. This invention uses what is called static electricity, and it makes every running train of cars a telegraph station, accessible to every other telegraph station on the road. Messages may be sent to and from conductors, and to and from passengers. It requires no extra wire, either under the cars or at the side of the cars, but uses the ordinary telegraph just as it is put up at the side of the track. This white board is a receiver and transmitter. A board like it is to be fastened lengthwise along the peak of each car, where it will be out of the way and will not be a blemish. When the train is telegraphed to, the message jumps from the wire on the side of the track and alights on this board, and is conveyed to the battery in the train below. It works beautifully from those wires strung yonder. I was as much astonished as anybody

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at finding out what could be done. It costs very little, moreover, as 300 miles of road can be equipped for 1,000 dols."

ELECTRIC HIGH AND LOW WATER DETECTOR.—A description of a new electric high and low water detector appeared in a recent issue of the *Scientific American*. The apparatus is substantially as follows:—"A galvanised iron stand pipe, about five inches in diameter, and of suitable length, is connected with the boiler by two pipes. Within the pipe is a float having a stem a little longer than the range between high and low water. The stem passes through a guide, and has a copper disc near the float, to signal high water, and another near its upper end, to make the connection for low water. The hole in the guide is bevelled to prevent the binding of the stem when the float shifts from side to side. The discs may be placed at any point on the stem. The electric circuit is completed through binding posts, which are connected with wires leading to an annunciator. The inner end of each post carries a copper plate, with which the discs come in contact as the float approaches either the high or low water level, and in order to insure proper electrical contact each plate is slitted into separate fingers in the bearing parts; the yielding of the fingers affords more certainty of connection with both plates, in case the float should happen to incline a little more to one side than the other. The discs are placed a considerable distance above the water, where they will not be liable to be fouled with deposits. When several boilers are provided with the detector a multiplex annunciator is used, so that each boiler may be represented by a special signal. The binding posts are insulated from the stand pipe by means of a rubber tube and washers, fitted through the holes of the pipe, and against the sides between a collar and a nut. This apparatus is now in successful operation at the nail works of the Ellis and Lessig Steel and Iron Company, of Pottstown, Pa. When the alarm is sounded the annunciator not only shows which boiler is in trouble, but also indicates whether it is high or low water."

LIGHTING OF A MINE IN NEW ZEALAND.—The Kaitangata Railway and Coal Company's mine has recently been lighted by electricity. Our contemporary the Otago *Daily Times* says:—"If the experiment is satisfactory, the mine manager states that the light will be permanently adopted for working the mine. The contrast between the ordinary flare or oil lamps used by the miners and the electric lamps was very striking. The fumes are smoky and dirty, and to unaccustomed eyes seemed only to make the surrounding darkness more intense; on the other hand, the electric lamps shone out bright and clear, penetrating the gloom and enabling the visitors to see all that was to be seen. The electrical apparatus was lent for the occasion by Messrs. R. E. Fletcher and Co., electrical engineers and contractors, of Dunedin. The installation was necessarily of a temporary character, having been all erected in a couple of days. Samples of the various fittings used where the light is installed as a permanency were shown in working order at the entrance of the tunnel, so that visitors who did not care to venture into the workings were able to examine and have the working of the apparatus explained to them. Although the Kaitangata mine is one of the first in this colony to use the electric light underground, electrically lighted mines are by no means such a novelty as many people would suppose. In the various Australian Colonies, notably Victoria and Queensland, there are no less than 15 gold and one coal mining companies which have adopted this new system of lighting both their surface and underground works. In some of these mines the light has been in successful use for nearly three years. When it is remembered that an ordinary candle vitiates as much air as two human beings would, and that these small electric lamps, being hermetically sealed in a glass bulb, can neither consume any oxygen nor vitiate the air in any manner, this fact alone speaks volumes in favour of the use of the electric light in places such as these, where the problem of efficient ventilation is always a difficult one to solve, to say nothing of the fact that neither wind nor water extinguishes it."

AN ALARM CANDLE BALANCE FOR PHOTOMETERS.—An ingenious automatic method for signifying the rate of consumption of candles used in photometrical work has, says the *Journal of Gas Lighting*, been devised by Dr. Hugo Krüss, of Hamburg, for the gas examiners of St. Petersburg, and has been recently described and illustrated in the *Journal für Gasbeleuchtung*. The arrangement is very simple. The candle-holder is hung in an unequal arm balance, as in the Sugg-Letheby photometer, in the position required for making an observation. The beam of the balance has a long pointer hanging down from the fulcrum, which marks the position of the balance on a vernier scale at the foot of the pillar. There are, as usual, two metallic pins at the two opposite ends of this scale, and in the middle a movable pin which is in electrical connection with a battery and a bell. Directly the pointer comes into contact with this pin the circuit is completed and the bell rings. The method of using the balance is readily understood. The candles being lighted and fixed in position are weighed until the pointer just swings clear of one stud of the vernier, when any desired weight may be placed in the pan provided for the purpose underneath the candles, the clock being started at the same moment. Observations may then be taken while the candle burns; and the instant the weight placed in the pan is lifted by the consumption of the candles and the weight in the opposite pan, the pointer swings back and touches the pin, which completes the circuit and so rings the bell. This, of course, indicates, in conjunction with a glance at the clock, the precise rate of consumption of the candles, without touching or in any way interfering with them. The arrangement is a very neat one, the battery, electro-magnet, and bell being mounted on the balance stand, and all contacts being so placed as to be readily removed out of the way when not required. For this a special form of cell is used, with an arrangement for preventing waste when not required for the purpose specified.

THE ELECTRIC LIGHT AT BOCKING PLACE.—An Essex contemporary says:—"The instances of the introduction of the electric light into private houses are at present so few, that we were pleased to have the opportunity of inspecting the results of the laying on of the light at the residence of Mr. S. Courtauld, of Bocking Place, which has just been carried out by the Consolidated Electric Company, of 68A, Cow Cross-street, E.C. The experiment appears to be an entire success, the house being brilliantly and effectively lighted by 64 Swan incandescent lamps, which are entirely under control by means of 'switches' conveniently arranged; and the ease and simplicity with which these are worked, and by means of which the lamps are instantaneously lighted, and as instantaneously extinguished, is remarkable. In the drawing room there are eight 16-candle lamps, which are so arranged that they can all, or any number of them, be lighted at once. In this room are two new developments of electric lighting—one a reading lamp, which can be moved about on the table as may be desired, or can be instantly disconnected and taken away, the circuit being completed by pressing into two small invisible holes in the table the ends of two wires attached to a small button. The table can also be moved to any part of the room; there is likewise a movable hanging lamp over the piano, which can be raised or lowered at will. The lighting of the billiard room

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is very successful, there being no shadow upon the table. Mr. Courtauld has had the light, or the wires, carried all over the house—from the cellars to the bed rooms, including kitchens and offices—and one of the most striking features in the system adopted is the use of accumulators, or receptacles for the electricity, which is stored much after the fashion of gas in a gasometer, the result being that by working the engine a few hours every day sufficient electricity is generated and stored to last many hours. The lamps vary from 10 to 50 candle-power each. There is no danger from fire, as if any of the wires should by accident become heated a small magnet is brought into play, which instantly and automatically disconnects the whole system from the accumulators. The motive power is a three and a-half horse Otto gas engine, *and the gas consumed, we are informed, actually produces more light in electricity than it would if burnt in the usual manner.* The whole cost of the installation, including enginehouse, engine, dynamo, accumulators, wire, electroliers, brackets, lamps, and labour was, we believe, under £500. Of course a long period of working is the only real test of actual success, but there appears in this case every probability that this has been obtained."

PRODUCTS OF THE ELECTROLYSIS OF DILUTE SULPHURIC ACID.—Mr. F. Richarz has recently treated this question. The experiments of Faraday, Schönbein, and others have demonstrated that by the electrolysis of dilute sulphuric acid there are formed, besides electrolytic gas, hydrogen peroxide, and ozone, to which Berthelot has recently added persulphuric anhydride, S_2O_7. In this paper experiments are detailed, tracing the connection between the proportion of ozone, hydrogen peroxide, and persulphuric anhydride formed, and the conditions of the experiment. The observation of Schönbein, that for the formation of a considerable quantity of hydrogen peroxide a considerable electric intensity is required at the positive electrode, and a low temperature, was at first confirmed. But in the course of the research it was noticed that the mutual reduction of the hydrogen peroxide and the persulphuric anhydride at the negative pole (a probable assumption of Hoffmann and Berthelot) causes a quantity of hydrogen, corresponding with a certain quantity of oxidising or available oxygen, to disappear, and thus cause a deficit in the products of electrolysis. Thus the sum of the evolved electrolytic gas, of the oxygen evolved as ozone, and of the oxidising or available oxygen in the persulphuric anhydride, is always less than the volume of electrolytic gas, as calculated from the observed deviation of the tangent galvanometer. Mr. F. Richarz considers that this deficit is caused partly by the reduction of the persulphuric anhydride, and partly by the absorption of the electrolytic gas by the dilute sulphuric acid. By increasing the temperature this deficit decreases, owing, firstly to the decrease of persulphuric anhydride formed, and secondly to the diminution of solubility of the electrolytic gas. It is remarked incidentally that the proportion of persulphuric anhydride formed decreases with rise of temperature more rapidly than that of the ozone. The influence of the duration and intensity of the current and also of the concentration of the acid on the relative proportions of the products of electrolysis is also discussed. It is shown that the proportion of persulphuric anhydride, ozone, and the deficit observed increases with the time of passage of the current, whereas an increase of intensity of current produces precisely the reverse result; this is in accordance with Wiedermann's observations. As regards the effect of concentration, the results given in tables show that with an acid containing 10-20 per cent. H_2SO_4 the proportion of oxygen as ozone and persulphuric anhydride, as also the deficit, is small, and no hydrogen peroxide is formed; with an acid containing 20-40 per cent., the proportion of oxygen as persulphuric anhydride and the deficit increases; with acids containing 40-90 per cent., the proportion of oxygen as ozone and persulphuric anhydride and the deficit decreases, whilst the proportion of hydrogen peroxide *pari passu* increases. The author proposes to examine the important question of the effect of the electromotive force of polarisation on the formation of these peroxides.

BRAUER'S DYNAMOMETRIC BRAKE.—According to the *Proceedings* of the Institution of Civil Engineers, two striking characteristics distinguish this brake, the invention of Mr. Brauer, from others of the same class. Firstly, it does not require when in action that its frictional surfaces should be constantly wetted; with ordinary wooden brakes this is absolutely necessary. Secondly, once the clutching action is established the brake regulates itself automatically, and further, there is not required, as with the ordinary brake, a long and cumbersome lever. An analogous arrangement to that of Mr. Brauer has been suggested by Mr. Kratz in his essay upon the dynamometric brake. In the Brauer apparatus, instead of wooden jaws hugging the rims of the pulley, an iron band is used for flat rim pulleys, and wire ropes for grooved pulleys. The apparatus is composed of the following assemblage of parts:—1st. The iron band or wire rope. 2nd. The clutch-producing arrangement and the regulation of the tension of the clutch-producing bands or ropes. The clutch or pressure of the bands or ropes upon the surface of the rim of the pulleys produces a friction corresponding to the effective work of the motor. The moment of this friction multiplied by 2π gives the work produced per revolution. To calculate this it only needs to determine an equal moment given by the additional charge or weight p, augmented by the weight of the regulating organs, the two weights affixed to the axis of the pulley, and p the moment required to maintain the system in equilibrium. The iron band applied to an ordinary flat rim pulley is provided with four double guides to retain the band in position, which is fixed up from the underside by means of a stirrup bolt and link and a safety cord, in such a way as to allow the band to have a play of 100 millimetres. These safety measures can be modified according to local circumstances, and when the under part of the pulley or drum is inaccessible. The following is a summary of the observations made by Mr. Burghardt, who has carefully tested Brauer's dynamometric brakes:—Needle lubricators do not sufficiently lubricate the apparatus; tallow is preferable as the lubricating medium. The brake worked well during the time the temperature of the pulley-rim did not exceed 35° to 40° centigrade, and even up to 80° centigrade the action was still satisfactory, but the lubricating medium became too fluid, and was thrown off the grooves by the centrifugal force due to the speed of the pulley. The Brauer brake worked well for two hours with a load corresponding to 25 horse-power. Summary of the advantages and disadvantages of the Brauer brake over those of the ordinary description:—1. The necessity of continually cooling the pulley-rim by subjecting it to a stream of water, which is a great drawback to the use of ordinary brakes, is in the Brauer brake avoided. 2. The brake is not so cumbersome, and can be applied to motors *in situ* and in confined spaces. 3. The oscillations are very limited, and consequently the observations are more exact than with the ordinary brake, and the diagrams obtained by the indicator are clean and clear, and easy to calculate. On the other hand, the Brauer brake is relatively rather more costly than those of the ordinary class, and it requires in its application a little more care than those of the ordinary and unscientific class.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 7.)

Impressed Electric Force in Dielectrics.

A comparison is often made between distributions of magnetic induction and of electric current. There is, however, a far more satisfactory analogy between magnetic induction and electric displacement in a dielectric, which may be pushed much further before correspondence ceases. So far as mere distributions in space go, of the three phenomena of conduction current, electric displacement in a dielectric, and magnetic induction, we may conveniently compare them simultaneously.

First let there be a distribution of impressed electric force e_1, in a conductor of conductivity k (infinitely extended in the general case, with the conductivity different at different places), setting up a steady state of electric force E_1, and conduction current C. We have the three conditions

$$C = kE_1, \qquad \text{div. } C = 0, \qquad \text{curl } (e_1 - E_1) = 0. \quad . \quad (80a)$$

Secondly, in a non-conducting unelectrified dielectric of capacity c, in which a distribution of impressed electric force e_2, sets up a steady state of electric force E_2, and displacement D, we have

$$D = cE_2/4\pi, \qquad \text{div. } D = 0, \qquad \text{curl } (e_2 - E_2) = 0 \quad . \quad (80b)$$

Thirdly, in a medium of permeability μ, in which a distribution of impressed magnetic force h, sets up a steady state of magnetic force H, and induction B, we have

$$B = \mu H, \qquad \text{div. } B = 0, \qquad \text{curl } (H - h) = 0. \quad . \quad (80c)$$

These three sets of conditions are exactly similar. We have in each case a "force" and a "flux." The first condition is the linear relation between the force and the flux, *i.e.*, Ohm's law, &c. The second condition is that of continuity of the flux, asserting that its divergence or convergence is zero everywhere, or that the flux is distributed entirely in closed tubes. The third is the force equation, what the equation of induction becomes when the state is steady, the third conditions in (80*a*) and (80*b*) being examples of curl $(e - E) = \mu\dot{H}$, with $\dot{H} = 0$, and that in (80*c*) arising from curl $(H - h) = 4\pi\Gamma$ with $\Gamma = 0$. The difference between the actual and the impressed force, or the natural force of the field itself, has no rotation, or its line integral round any closed line whatever is zero. Or,

$$E_1 = e_1 + F_1, \qquad E_2 = e_2 + F_2, \qquad H = h + F_3,$$

where F_1, F_2, F_3 are "polar" forces entirely, derived from single valued scalar potentials, whose space variations give the polar forces; thus $F_1 = -\nabla P_1$, $F_2 = -\nabla P_2$, $F_3 = -\nabla\Omega$, where P_1 and P_2 are electric potentials and Ω magnetic potential.

The three conditions serve to determine unambiguously the complete solution, so far as the force and the flux are concerned, when the impressed force and the distribution of conductivity, &c., are given. To the impressed force we require to add a polar force to make up a complete system of force satisfying the continuity of the flux. At the poles, or places where the polar force converges, or diverges, we may, if we like, put imaginary matter, electric or magnetic, as the case may be, repelling according to the inverse square law, and regard the potentials as the potentials of the matter. Each distribution of impressed force requires a particular polar force to supplement it; except when the impressed force is so distributed that it can by itself satisfy the continuity of the flux, and the linear relation between the flux and the force. Thus, when div.$ke_1 = 0$, or div.$ce_2 = 0$, or div.$\mu h = 0$, no polar force is needed, and there is none, or the potential does not vary. We have then $C = ke_1$, $D = ce_2/4\pi$, and $B = \mu h$ respectively. On the other hand, should the impressed force be itself polar in its distribution, there is no flux produced. We then have $e_1 = -F_1$, &c., and $E_1 = 0$, &c.

Now, if in the above three problems, the distributions of impressed force—electric or magnetic, as the case may be—are identical, and also the distributions of conductivity, &c, in space, then also the three fluxes have identical distributions. Practically, as neither the permeability nor the capacity (in non-conductors, at any rate) can vanish, we must not let the conductivity be zero anywhere in the conduction current problem; *i.e.*, all space must be conducting, more or less, to get identical distributions of current to those of induction and displacement respectively. We cannot confine either of the last to definite closed channels, as we do electric currents, by arrangement of matter, although we can do so by proper distributions of the impressed force, viz., in the above mentioned cases of no polar force.

The distributions of Joule heat per second (or dissipativity) of electric energy (or energy of displacement), and of magnetic energy are also similar, being E_1kE_1, $E_2cE_2/8\pi$, and $H\mu H/8\pi$ respectively per unit volume, and if their totals through all space be Q, U, and T, respectively, we have

$$Q = \Sigma E_1kE_1 = \Sigma e_1kE_1 = \Sigma e_1ke_1 - \Sigma F_1kF_1 \quad . \quad (81a)$$

$$8\pi U = \Sigma E_2cE_2 = \Sigma e_2cE_2 = \Sigma e_2ce_2 - \Sigma F_2cF_2 \quad . \quad (81b)$$

$$8\pi T = \Sigma H\mu H = \Sigma h\mu H = \Sigma h\mu h - \Sigma F_3\mu F_3 \quad . \quad (81c)$$

In the first form of expression, as ΣE_1kE_1, the quantity summed is the actual amount in the unit volume. In the second form the summation extends only where there is impressed force, being of the scalar product of the impressed force and the actual flux.

In the third form, there are two summations, both necessarily of positive amounts, whose difference gives the dissipativity, &c. The first extends only where there is impressed force, being the greatest value of Q, &c. The second extends over all space where there is polar force, and vanishes when there is none. The parts depending on the polar forces may also be expressed in terms of the potential and of imaginary matter. Thus—

$$\Sigma F_1kF_1 = \Sigma P_1\rho_1, \text{ if } \rho_1 = \text{conv.}ke_1, \quad . \quad . \quad . \quad (82a)$$

$$\Sigma F_2cF_2/8\pi = \Sigma\tfrac{1}{2}P_2\rho_2, \text{ if } \rho_2 = \text{conv.}ce_2/4\pi, \quad . \quad . \quad (82b)$$

$$\Sigma F_3\mu F_3/8\pi = \Sigma\tfrac{1}{2}\Omega\sigma, \text{ if } \sigma = \text{conv.}\mu h/4\pi. \quad . \quad . \quad (82c)$$

Note here that the distribution of imaginary matter is not the same (in general) as that before mentioned, measured by the divergence of the polar force. Here the matters are distributed where the impressed force, multiplied by the conductivity, &c., has convergence. In (82*c*), σ is the density of imaginary magnetic matter on the ends of a magnet. But in (82*a*) and (82*b*), ρ_1 and ρ_2 are not distributions of electrification, for there is none in either case. The electrification is measured by the divergence of the displacement, which is zero under the stated conditions.

We may also employ vector potentials in all three cases. Thus

$$Q = \Sigma E_1C = \Sigma H_1G_1 \quad . \quad . \quad . \quad . \quad . \quad (83a)$$

$$U = \tfrac{1}{2}\Sigma E_2D = \tfrac{1}{2}\Sigma ZG_2 \quad . \quad . \quad . \quad . \quad . \quad (83b)$$

$$T = \tfrac{1}{2}\Sigma HB/4\pi = \tfrac{1}{2}\Sigma A\Gamma \quad . \quad . \quad . \quad . \quad (83c)$$

The relations of these new quantities are

$$\text{curl } H_1 = 4\pi C, \qquad \text{curl } e_1 = 4\pi G_1, \quad . \quad . \quad (84a)$$

$$\text{curl } Z = cE_2, \qquad \text{curl } e_2 = 4\pi G_2, \quad . \quad . \quad (84b)$$

$$\text{curl } A = \mu H, \qquad \text{curl} h = 4\pi\Gamma, \quad . \quad . \quad (84c)$$

In the conduction current case (83*a*) and (84*a*), H_1 is the magnetic force of the current, and G_1 is an imaginary distribution of magnetic current, viz., where the impressed force has rotation, or varies laterally. In (83*b*) and (84*b*) G_2 is also an imaginary magnetic current, similarly related to the impressed force, whilst in the magnetic case (83*c*) and (84*c*), Γ is similarly related to the impressed magnetic force, and is the well-known imaginary electric current which would (if it were a real current) correspond to the same state of magnetic induction as the impressed force h sets up. The summations do not extend over the whole region of impressed force, but to portions only, perhaps round a single line. This we will illustrate in the conduction current case. The formula $Q = \Sigma H_1G_1$ has some suggestiveness in connection with the transfer of energy, but turns out to have no very important application. As we remarked before, if the impressed force be polar, there is no flux. For there to be any flux at all, the

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impressed force must have curl somewhere, and $Q = \Sigma H_1 G_1$ shows the exact dependence of the activity on the situation and amount of this curl. Take a simple voltaic circuit, copper and zinc in acid, and the copper continued by a copper wire to the zinc outside the liquid. Suppose the impressed forces are entirely confined to the metal-acid surfaces, and are of uniform strength over each metal. Then the places of summation are the two wind and water lines. One place gives the amount of energy leaving the zinc per second, the other the amount arriving at the copper, and their difference is the amount of Joule heat in the circuit. Next suppose that the zinc-air force equals the zinc-acid force, and that the copper-air force equals the copper-acid force. There is now only one place of curl of impressed force, viz., the air boundary of the copper-zinc junction, and the summation round that line only gives the value of Q. But not only may we thus shift the places of summation outside the battery, but we may locate them altogether away from the circuit if we like by suitable dispositions of impressed force outside the circuit, which will not in any way disturb the state of magnetic force and current provided we keep the same impressed forces in the battery as before, although they will alter the paths of the transfer of energy. In problems (*b*) and (*c*) there is, of course, no transfer of energy at all after the steady states, which are alone considered, have been set up.

In problems (*b*) and (*c*) we may also compare the mechanical stresses. They are such as to increase U or T respectively when allowed to act, by letting the impressed forces do more work. Two bar magnets repel with like poles, and attract with unlike poles approached, whilst either pole of either will attract soft iron and repel bismuth. Similarly, take two bars of a dielectric and put in them impressed electric force parallel to their lengths. Like ends will repel and unlike attract one another, whilst either pole will attract a piece of solid dielectric of greater capacity than air (in which all are immersed), in which there is no impressed force, or repel it if its capacity be less than that of the air, or other surrounding medium. The same will happen if there be intrinsic displacement in the solid bars, such as arises from so-called "absorption." (If in the conduction current problem there were a corresponding tendency for Q to increase, then a copper ball in mercury conveying a current would be attracted by either electrode, where the current has greater density.)

Dismissing now the problems (*a*) and (*b*), consider something quite peculiar to (*c*), that of dielectric displacement. Both the conduction current and the magnetic induction are continuous, as expressed by the second condition in each case. We have also written down the same condition for the electric displacement. No arrangement of impressed electric force can *create* any discontinuity in the displacement, provided there be no conduction anywhere. Should there be any discontinuity, its proper measure is the divergence of the displacement. That is, ρ the volume density of the electrification—for it is nothing else than discontinuity in the displacement—is given by

$$\rho = \text{div.D}.$$

Supposing there to be any such discontinuity, it will remain a fixture, or only be varied in distribution by motion of matter carrying the electrification with it—of matter, because it appears most probable that there cannot be any electrification without the presence of matter; or, the displacement in the electro-magnetic medium itself, the ether, is always continuous. To get rid of the electrification there must be conduction. Conversely, to create electrification there must be conduction. The two statements go together.

Now the essential property of a conduction current is dissipation of energy by the heating effect produced. Destruction of electrification by disruption of the dielectric is therefore of the nature of a conduction current, at least partly, although the simple metallic conduction law is not followed, and, in fact, it is not known definitely what is the exact course of events, even when considered merely electrically. But we should never, in attempting to explain something, go from the complex and ill-understood to the comparatively simple and mathematically expressible, but pursue the other course. We may say then, with tolerable certainty, that to create electrification there must be (1) the presence of matter; (2) impressed electric force, *i.e.*, a cause in operation which tends to produce an electric current (if we like we may say which tends to produce magnetic force, and regard the current as an affection of the magnetic force), which is neither the polar electric force nor the electric force of induction, these being the only two naturally belonging to the electro-magnetic medium; (3) conduction, with dissipation of energy.

Nothing is easier than to create electrification experimentally or involuntarily by the contact or friction of bodies. Imaginative explanations may be readily made up, and are likely to be of very little value. It is, then, necessary to be somewhat general, or vague, in order to keep on the straight and narrow path. We may create electrification by the contact of different conductors, either by means of the small known contact force of thermal origin, or of the much larger air-surface contact forces of chemical origin, and, so far, it is easy to recognise the presence of the matter, of the impressed force, and of the conduction. Similarly, by the contact of a conductor and a dielectric, if there be similar impressed forces present. No friction is absolutely necessary. But if we set two dielectrics in contact, without any connection with conducting matter, no impressed electric forces can, without a change of conditions, set up any electrification. Some friction is needed, and with it there is conduction, or equivalently disruption. The actual original impressed electric forces need not be great, and are probably small. It is the act of separating mechanically the opposite electrifications produced by the friction, at first extremely close together, that is the main cause of the high difference of potential observed after separation, together with the similar separation taking place during the friction. The electric field is, for the most part, set up during the separation, and derives its energy in the main from the mechanical work then done.

Now, having got electrification—ρ per unit volume, say—the field due to it is settled by the three conditions,

$$\text{D} = c\text{E}/4\pi, \qquad \text{div.D} = \rho, \qquad \text{curlE} = 0 \quad . \quad . \quad . \quad (85)$$

differing from the former, equations (80*b*), in the second and third, in the absence of impressed force and the existence of ρ. The field is definitely determined by (85); the force is polar completely, and the energy is

$$\Sigma \text{E}c\text{E}/8\pi = \tfrac{1}{2}\Sigma \text{P}\rho,$$

if P be the potential.

Should there be also impressed forces, the actual field will be the sum, in the vector sense, of the two fields, due separately to the electrification and to the impressed forces. Not only that, but the total energy of displacement will be the sum of the amounts in the separate fields; or, the mutual energy of the two fields is zero. This is true because the displacement in the field of the impressed force is everywhere continuous, and the force of the other field wholly polar.

Electrification has no magnetic analogue, the magnetic induction being always continuous. It is important that the distinction between electrification, as above considered, and *imaginary* free electricity (as when the force is discontinuous, though not the displacement) should be clearly recognised. The latter is the analogue of free magnetism.

Similarly, there is no electrification in a conductor supporting a current, provided it be not dielectric as well. In the latter case it is the true current, the sum of the conduction and displacement current, that is continuous, making them sometimes separately discontinuous, thus

$$-\text{div.C} = +\text{div.}\dot{\text{D}} = \dot{\rho}; \quad \text{div.}\Gamma = 0;$$

C being the conduction, $\dot{\text{D}}$ the displacement current, and their sum Γ. It is usually only at the surface of a conductor that there is electrification; should, however, the specific capacity of the conducting matter itself be variable from place to place, there will generally be interior electrification as well, during the existence of a conduction current.

The consideration of the particular kind of dielectric displacement concerned in the phenomenon of absorption must be left over.

(To be continued.)

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RECENT ELECTRIC LIGHTING INSTALLATIONS.

It was perhaps with a sense of thankfulness for small mercies that such unwonted interest was manifested in the two papers read before the Society of Telegraph-Engineers and Electricians last Thursday fortnight. So far as they went those papers were satisfactory and encouraging; but they did not, it must be confessed, go very far. Of the two, Mr. Shoolbred's was the most instructive, as was to be expected, Mr. Farquarson's being mainly interesting from the fact that the experimental trials described by him had resulted in a decision which will lead to large Government orders for the electric lighting of a number of Her Majesty's ships of war. There are obvious advantages for the application of electric lighting on board steamships of every kind, and we have always predicted that a wide field for enterprise would open up in this direction when those advantages came to be known. For the mercantile marine there never was a doubt as to the superiority of electricity, when steam power is available, over the oil lamps usually employed, in respect both of cheapness and efficiency. The doubt as to its applicability for the Navy —or rather as to its chances of competing economically in that quarter—has been set at rest by the recent experiments on board the "Colossus," instituted under orders from the Admiralty by Mr. Farquharson.

The doubts to which we have referred were chiefly in regard to the well-known fact that on board Her Majesty's ships of war steam at low pressure is usually employed for economic reasons, and it had been feared that this would prove a most extravagant mode of supplying power to electric lighting Indeed, this was actually seen to be the case by the figures adduced with Mr. Farquharson's paper, some experienced electric lighting engineers pointing out that if the competition had been against a less expensive mode of lighting than that which prevails in such ships as the "Colossus" the experiment must have failed. But it did not fail; on the contrary, it showed that a large, a very large, saving would be effected by substituting electricity for oil as an illuminant, notwithstanding the circumstance that the electric lamps were maintained under the most wasteful conditions—conditions which on land would be fatal to its success as a competitor against any other illuminant whatsoever.

In some other ways the experiment does not appear to have been carried out on very careful lines with a view to economy. This is shown in the number of breakages to lamps, no fewer than sixty-three being destroyed out of a total of four hundred during the short period of seven days. Either there was reckless consumption of energy, or carelessness in the choice of lamps for this installation. But as the cost of renewals was added to the bill, and the average annual outlay based upon the data supplied by the seven days' lighting, the result is all the more favourable to the system. In actual practice dynamos will probably be constructed better adapted for low pressure steam-power, and there will certainly be no such destruction of lamps as occurred on the "Colossus." It follows, therefore, that the result of the trial which proved so satisfactory to the Lords of the Admiralty will be followed by results still more satisfactory, and that their Lordships will have no reason to regret the general introduction of electric lighting throughout the Navy.

The life of the incandescent lamps is a matter of much importance, quite apart from the question of cost. On board these ironclads, for example, which have sometimes been described as iron pots floating with their lids above water, light is required in many parts both day and night continuously, and in all sorts of out-of-the-way spots. Failure of a lamp in these circumstances is highly inconvenient, and might at times be attended with serious consequences. It is reassuring, therefore, to learn, both from the paper which followed on the lighting of the Forth Bridge Works and from the testimony of other experts present, that the failure of an incandescent lamp is generally preventible, the prolongation of its life almost indefinitely being secured partly by better construction, but mainly by the avoidance of currents which tax the filament to its nominal, that is to say utmost, capacity of endurance. Mr. Siemens told the meeting that quite a large number of the lamps originally introduced at the Savoy several years ago were still holding out, and these, of course, were of a pattern which had been greatly improved upon since that theatre was electric-lighted. The improvement in the manufacture of glow lamps in recent years was brought out very clearly by Mr. Shoolbred, who stated that whereas during the first half year's working at the Forth Bridge their average life was 404 hours, it had gone on increasing by improvements and superior workmanship, so that after an interval of barely eighteen months the average life had risen to 1,200 hours. It was also mentioned that a passenger steamship had made the out and home journey to New Zealand with the loss of only one lamp.

Of even greater importance is the continuity of the lighting, whether arc lamps or incandescent are employed, on such works as those now in progress across the Forth. Failure of any of the lights, either by stoppage of the engine or by breakage of wire, would be of serious consequence to the labourers, many of whom are at work below water. But although the installation is on a considerable scale, extending over an area of two or three miles, and the requirements of the most varied character, there has been no failure or mishap

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whatever from first till now. This we consider most gratifying, as it proves beyond doubt that when, as in this case an installation is put into the hands of competent Electric Engineers, those provoking "accidents" with which the electric light is so frequently taunted will never occur. We note with satisfaction also that the wires at Forth Bridge may be handled with perfect safety. A low E.M.F. has been used in deference, it is said, to the fears of the workmen. We should prefer to describe it as an act of common prudence; anyhow, there will be no accident of the kind which has caused so much terror elsewhere, and it is plain that there never need be any such accident again.

On the whole, therefore, these two installations, for purposes widely differing in character, are full of encouragement, and will be the means of expanding the electric lighting business in new directions, of which business men will not be slow to take advantage. In other directions—for example, in the matter of street lighting, notably in the metropolis—progress is slow; and according to a recent annual report of the Board of Works there has been a "temporary retrogression," owing to circumstances which the Board deplores as much as we do. Its failure to obtain successors to the work undertaken by the now defunct Jablochkoff Company for lighting the Victoria Embankment and Waterloo Bridge is quite intelligible, though the Board think it regrettable. The terms on which these or any other badly lighted localities can be rendered cheerful and safe are such as the Metropolitan Board of Works may, if it chooses, lend its powerful aid in obtaining; and we note as an indication of its willingness to help to this end that it is "making inquiries with reference to the most suitable and economical method of lighting by electricity." Its real difficulty will be to discover the most effectual way to overcome the unnatural obstacles which have been placed in the way of this most "suitable and economical method of lighting."

CORRESPONDENCE.

APPLICATION OF PHOTOGRAPHY TO ELECTRICAL MEASUREMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your edition of yesterday (5th June), under the heading of "Application of Photography to Electrical Measurements," the credit of the idea is given to the Americans. As a matter of fact, I have employed this method myself last year in order to obtain an accurate ammeter recorder (or registering current meter, as these instruments are sometimes called); also for a register of E.M.F. The means employed were very similar to those described, and to obtain the average current or E.M.F. over a given time the curve was integrated by the use of a planimeter.

I had an interview with Mr. Gisbert Kapp (then of Messrs. Crompton) in September last, with a view of making such instruments and others for commercial purposes, but the expense stood in the way.—Yours, &c.,

London, June 6, 1885. DAVID SALOMONS.

BLIND MATHEMATICS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: *Re* the correspondence under the above heading in your last issue, a practical proof may show Mr. Williams the mistake he is making in regarding the expression $\frac{E^2}{R}$ for the rate of development of heat in a wire as fallacious and "deceiving the scientific world."

First, let us say that before we can compare the heat developed in two or more wires by means of their respective resistances we must know whether the current passing through them both is the same, which would be the case if they were connected one after the other in series in a circuit, or whether they are both acted on by the same electromotive force, which would be the case if they were connected in parallel arc, and their combined ends joined to a battery or dynamo.

Take a platinum wire, A, and a silver wire, B, identical in size and length. A has six times the resistance of B.

1. Let the current be the same through both by placing them in series in a circuit. The platinum is heated more than and long before the silver, the heat varying (by $C^2 R$) simply as their resistances, the current being the same in each.

2. Place the wires in multiple arc, and then in a circuit. We have now the same E.M.F. at the terminals of both, and since their resistances are not the same we cannot have the same current passing through each, by Ohm's law the current in B being six times that in A. Now, by the expression C^2R for rate of heating, which your correspondent admits, we have the ratio of the

$$\frac{\text{Heat in A}}{\text{Heat in B}} = \frac{(1)^2 \times 6}{(6)^2 \times 1} = \frac{1}{6}.$$

The silver wire is, therefore, heated first, and six times more than the platinum.

Has Mr. Williams never noticed the difference in brilliancy of glow lamps working in parallel? Which are the brightest? Those of least resistance. If he doubts it let him test them. Or take a more apparent case, thus: while a circuit of Swan 20-candle lamps of, say, 35 ohms each, hot, are running in parallel, let him take one off and put in its place one of the new Edison-Swan 20-candle lamps of, say, 160 ohms hot; the latter would burn dim red if at all, only getting about a third its required current. It would need no "blind mathematics" to see this effect.

If we establish beyond controversy two laws

$$C = \frac{E}{R} \quad \text{and} \quad H = C^2 R,$$

giving the *same* meaning to R in both cases, it is mathematically legitimate to interchange, substitute, or connect these expressions as we like, to form new expressions as correct as the laws from which they are derived.

Blind and groping mathematicians must envy your correspondent his clear vision to see the darkness they are in.—Yours, &c., H. D. WILKINSON,

School of Electrical Engineering, Hanover-square, W.
June 8th, 1885.

ELECTRIC CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I should be greatly obliged by your informing me through your correspondence column the greatest length through which electric current has been transmitted for the purpose of electric lighting—I do not mean as a *tour de force*, but for practical, permanent lighting—with the name of the locality where such lighting is carried out.—Yours, &c.,

ADOLPHE DE BROMWERE,
Brussels, 9th June, 1885. Ingènièur Civil, Bruxelles.

ARMATURE WINDING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the comparison between the resistances of the Gramme and Siemens armatures in Mr. Kapp's article on the "Design of Dynamos" (page 23) an incorrect result has been arrived at owing to taking the length of wire on a Siemens armature as $n(b + 1{\cdot}3d)$ instead of $2n(b + 1{\cdot}3d)$.

The difference between the respective lengths of wire on the Gramme and Siemens when the length b of their armatures is the same, would therefore be

$$2n(a - 1{\cdot}3d).$$

Now, if we make the ring and drum armatures identical in diameter and length, wind on the same number of turns on each, and take $a = {\cdot}175d$ the ratio of their respective resistances will be $\frac{{\cdot}175d + b}{1{\cdot}3d + b}$.

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Hence, if $d = b$ the resistance of the wire on the drum would be nearly double that on the ring, and their resistances would approach equality as b was increased; but it is evident that no relation between d and b would equalise their resistances, for a similar number of turns, so long as the lengths and diameters of their armature cores remained the same.

We may, however, determine their relative economy of winding by the ratio between the number of turns of wire on each necessary to equalise their resistances. This ratio for the ring and drum respectively would be the reciprocal of the last expression.—Yours, &c., H. D. WILKINSON.

School of Electrical Engineering,
Hanover-square, W.

NOTE ON THE REGULATION OF DYNAMOS

(Continued from page 60.)

In the former note the condition of regulation was found to be fulfilled when $N b = r$, and it was pointed out that wherever the relations of speed and initial excitation made this possible the machine would give a constant difference of potential at its terminals. This condition is fulfilled in the compound machine at several different speeds, and the machine regulates well at these speeds in consequence; but the speed for regulation is limited on both sides. If the speed is too low the difference of potential at the terminals rises as the current through the lamps increases; if the speed is too high the difference of potential falls as the current increases—in the first case, due to the low initial saturation produced in the

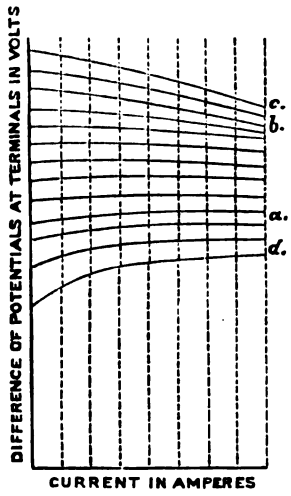

FIG 1.

magnets by the shunt coil $N b$ is greater than r; in the second case, due to the higher saturation produced by the shunt coil $N b$ is less than r. The diagram (Fig. 1) gives a set of characteristics of a compound machine for different speeds, the current in amperes in the outside part of the circuit being represented by distances along the horizontal line, and the corresponding difference of potential at the terminals by ordinates. It will be observed that the regulation is very good for several speeds corresponding to the curves from a to b, but that on each side of these curves the regulation is imperfect. It must be remembered that the rising of the curve at the lower speeds is not purely due to the additional excitement added by the series coil, but that the shunt coil also adds an increased magnetism as the difference of potential at the terminals rises. The effect is, therefore, due to the combined action of the series and shunt coils, although the rise is primarily due to the incorrect adjustment of series to shunt wire at the particular speed at which it takes place.

Referring to the experiment mentioned in the previous article of cutting out the shunt coil, Fig. 2 has been drawn to represent the exact effect produced by running the dynamo at a constant speed, and varying the resistance and consequently the exciting power of the shunt. As before, distances along the horizontal line represent current in the outer part of the circuit, and ordinates the difference of potential at the terminals. Curve a is obtained by cutting out the shunt wire altogether, or by putting into the shunt circuit an infinite resistance, which means the same thing. Curve b is the curve obtained with both series and shunt wire in action, the machine compounding as in the ordinary way. Curves c, d, and e are obtained by introducing into the shunt circuit various resistances, the resistance, of course, remaining unchanged, while the particular curve it corresponds to is being taken. The rise of the curve is in this case also due to the combined action of the series and shunt coils; as the potential at the terminals, due to the action of the series wire, rises, this rise is further exaggerated by an increased current flowing through the shunt coil, but when the shunt coil is excited from a second dynamo and the current kept constant, the same general features are exhibited by the curves.

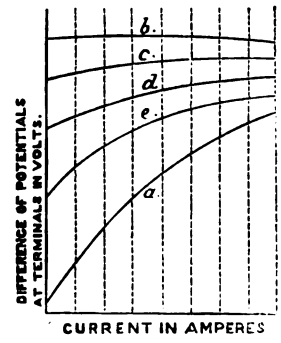

FIG. 2.

These considerations enable us to dispose of some errors which have necessarily characterised our ideas regarding self-regulating dynamos in consequence of our having assumed a straight line law for the saturation of the magnet cores. In a given machine having a certain resistance of armature and series coils and a certain series winding, it has frequently been assumed that if the shunt coil is separately excited by a second dynamo, and the difference of potential varied by altering this excitement, that the regulating speed of the machine remains unaltered. This would mean that the series wire has the same value as far as strengthening the field is concerned, whether the excitement furnished by the shunt coil is great or small, and such a condition can only be fulfilled if the straight line law is true. But no magnet cores in dynamos hitherto constructed are of the dimensions required to render such a law even approximately true, and from the diagram (Fig. 2) it may be clearly inferred that in the case of dynamos where the shunt is separately excited; as the excitement furnished by the shunt is increased or diminished, the speed of the machine must be increased or diminished if it is to regulate at the new difference of potential. This is really what is effected in the compound dynamo for all speeds where the machine regulates. The initial field furnished by the shunt is increased by the rise in speed which is necessary to fulfil the condition of regulation so far as the series wire is concerned.

It may be sometimes necessary to correct inaccuracies in the winding of compound dynamos without going to the trouble and expense of rewinding the machine, and the steps to be taken in order to effect this are indicated in the foregoing observations. Let us imagine that a dynamo has been wound which, *intended* to give a constant difference of potential at the terminals, gives instead a characteristic indicated by curve c. (Fig. 1), where, as the lamps are turned on, the difference of potential at the terminals gradually falls. Now, if the magnetism furnished by the shunt coil were independent of the speed, say as in the Deprez arrangement, where the shunt coil is separately excited, we could, by *increasing* the speed of the machine, straighten the line, whereas in the compound dynamo we can, by *reducing* the speed, do the same thing, as will be seen from Fig. 1. But in either case the difference of potential which would result would be useless for our lamps, assuming that that given by the machine as at present wound is correct when the full current is on. It will not serve our purpose to straighten the line with a reduced potential, but by inserting a permanent resistance into

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the shunt coil we can bring down the initial excitation, which the curve shows to be too high for regulation, and so make the machine regulate as well as if the series and shunt coils had been properly adjusted to each other in the winding. The speed will have to be somewhat greater that formerly, because the total excitation produced by both coils has been reduced; but the proper speed for regulation may be found by adjusting, by trial, speed and inserted resistance, until the desired effect is produced. By inserting a resistance in the shunt the efficiency of the machine has been increased.

Suppose, now, we have to correct the inaccuracy in a machine where the difference of potential rises considerably as the number of lamps is increased. This case is not so bad as the former, because there is no danger of breaking lamps in reducing their number; indeed it is necessary when running a machine with an engine not otherwise loaded to give a slight rise to the characteristic, so that the slightly increased speed of the engine, due to racing when lamps are turned out, is not a disadvantage. But in the present case we will assume that the rise is excessive, and that the characteristic of the machine is given by the curve *d* (Fig. 1). In the case of a machine having the shunt coil separately excited—the magnetism furnished by the shunt being therefore independent of the speed—the line might be straightened by *reducing* the speed, the potential being necessarily reduced at the same time, whereas in the case of a compound machine reducing the speed would only make matters worse. The line might be straightened in the present instance by *increasing* the speed, only the difference of potential would then be too great for the lamps. Obviously we can only make the machine regulate at the proper potential by increasing the initial magnetism supplied by the shunt coil, and this can be done by reducing the shunt resistance. We must therefore couple the shunt coils in two parallels, introduce a resistance into the shunt circuit, and adjust speed and inserted resistance until the required result is obtained. The regulating speed will be somewhat less than formerly, because the total excitation from both coils has been increased, and the machine may be made to regulate as well as if the series and shunt coils had been properly adjusted to each other in the winding; but in reducing the resistance of the shunt coils the efficiency of the machine has been diminished.

In conclusion, it may be pointed out that much of the reasoning here given is applicable to electro-motors wound differentially for constant difference of potential at the supply mains according to Ayrton and Perry's method. The saturation effect, which enables compound dynamos to regulate at several different speeds within certain limits, should enable compound electromotors to regulate at several different potentials, although running at different speeds. But this can be better discussed in a future paper.

W. B. ESSON.

THE THERMO-ELECTRICITY OF MOLTEN METALS.*

BY F. BRAUN (CARLSRUHE).

1. In a circuit of metallic conductors a current produced by difference in temperature must be the equivalent of heat derived from an external source. If we assume (1) that the process is reversible, (2) that heat is absorbed only at the point of contact of higher temperature, and is given out only at the colder point of contact, then it follows that the thermoelectric force must be proportional to the difference in temperature of the junctions for intervals of any magnitude. If we assume a change in potential function at both junctions, the result may be expressed thus: that the change in potential is proportional to the absolute temperature of the junction. The electromotive force therefore, expressed as a function of the difference of temperature, ought to be a straight line. But experiment shows that in all the thermopiles as yet examined this linear relationship does not hold good; in by far the majority of cases the curve is much nearer a parabola. This led Sir W. Thomson to the conclusion that even in the interior of one and the same metal unequally heated there must be produced, upon the passage of a current, a quantity of heat proportional to the first power of the current strength (adopting Le Roux's term, we may call this "the Thomson effect").

In fact, if the thermopile works, not between two temperatures, but between an infinite number, it follows inversely that its electromotive force can no longer be expressed as a linear function of the greatest temperature difference which occurs in it. Although, strictly speaking, nothing can be determined as to the locality of the electromotive force, yet we should be disposed to add to the changes in potential assumed to exist in the junctions (of which, however, no proof has yet been given that they occur there) other changes of potential occurring in the interior of the unequally heated metal.

Hitherto, so far as I know, only thermopiles have been examined in which at least one metal has been solid. The explanation is then obvious, that these internal thermoelectric forces are due to changes produced by the heat itself in the solid metal—hot and cold metal behaving like two different substances, or, as we may shortly express it, the heat produces structural changes. In fact, as shown by the experiments of Magnus, pieces of the same metal but of different temperature produce a thermoelectric current when brought quickly into contact. Only with lead could this result not be observed with certainty. But in lead, as Le Roux showed, the Thomson effect is nearly or quite zero. In general, those metals which show a large Thomson effect show also the further peculiarity that, upon heating a single wire the ends of which are kept at a constant temperature, a thermoelectric current is produced, the intensity (and even direction) of which often varies with insignificant changes in the distribution of the temperature or the structure of the wire.

These currents, I may at once mention, are so energetic, and especially so variable, particularly if the temperature is raised to a red heat, that I have had to take precautions with my thermopiles that there should not be any great differences of temperature in the solid metal. With lead only have I been unable to observe with certainty any such currents, even when the solid metal was plunged into molten lead. According to an experiment of Magnus's, often quoted, which for short I will call the Magnus experiment, currents are altogether absent in mercury.

It is an obvious explanation to refer the currents, produced on bringing together a cold and hot metal, to differences in structure (although we must then ascribe some influence either to time or to distribution of temperature), and to class them together with the Thomson effect—that is, the deviations which the thermoelectric force shows from proportionality with the temperature-difference. If certain metals give no thermo-current either in the Magnus experiment or when a wire, whose ends are maintained at a constant temperature, is heated, this may be explained in two ways: either changes of potential take place on both sides of the point heated, which, however, must decrease equally in both directions, or no thermoelectric excitation takes place, because, in consequence of the nature of the metal, differences in structure are impossible.

To this latter, although more special, assumption it seems to me we shall be most inclined. It is to be assumed that other molten metals will behave as mercury does, which, in fact, I have found to be the case (*cf.* § 7).

2. If we regard the Magnus experiment in this second way, it would follow that the thermoelectric force between molten metals must be proportional to the difference in absolute temperature between their points of contact. But this would show the possibility of measuring absolute temperatures to a very high point by a method presenting many advantages over measurements made with an air thermometer (smaller space of constant temperature, independence of expansion and changes in form of the vessel). We should further, and probably for the first time, obtain numbers which are entirely dependent upon the chemical nature of the substance, and free from uncertainties as to how hard or soft the body is. They would offer us a more ready conclusion as to the internal processes by which thermoelectric forces are excited. In fact, it appears very remarkable how,

* From the *Phil. Mag.* for June. Translated from the *Sitzungsber. der königl. Akad. d. Wissensch.* of Berlin, of April 9th, 1885.

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under similar external conditions (where any desired quantities of heat are available), large quantities of heat are transformed into the form of energy of mechanical work, at the points of contact of many metals, and with others very small quantities.*

Since, further, each molten metal in thermoelectric relationship must be characterised by a single constant (which no doubt may vary with the pressure), this must stand in some relationship to other constants, characterising the particular metal, and independent of the temperature; but of such there is only the atomic weight available.

3. These considerations induced me to measure the thermoelectric forces of molten metals against each other between as wide limits of temperature as possible. A linear dependence upon the temperature appeared to me *à priori* so probable, that I directed my attention from the first to the utmost possible chemical purity of materials, and, moreover, chose only elements. Alloys were investigated only in the second place.

In the following I give the combinations which were measured, as well as the range of temperature employed; t denotes the temperature of the colder points of contact, T the highest reached at the warmer point of contact.

NaHg ..... $t = 20°$ or $100°$; $T = 370°$.
PbHg ..... $t = 20°$; $T = 580°$.
KHg ..... $t = 20°$ or $100°$; $T = 520°$.
SnHg ..... $t = 20°$; $T = 460°$.
Hg(Na + K†) . $t = 20°$; $T = 380°$.
PbSn . . . . $t = 20°$; $T = 435°$; $t = 424°$; $T = 974°$.
BiSn . . . . $t = 508°$; $T = 882°$.
Hg(Hg + Bi + Pb)‡ $t = 20°$; $T = 530°$.

4. For the determination of high temperatures in spaces frequently small I employed spirals of platinum wire, whose galvanic resistance had previously been determined as a function of the temperature. I employed for this purpose a large muffle furnace heated by coal, the description of which, as well as of other experiments made with it, I propose to give shortly elsewhere. The vessels for the air-thermometer were made of Meissen porcelain.§ The dimensions could be so chosen that, assuming constancy of temperature, temperatures of 1,000° C. could be accurately measured to 1° or 2°.

5. The metals were enclosed in glass tubes, wherever glass could be used. Platinum wires melted into the glass served for external connections. With some metals the platinum wire was in direct contact with the metals; with others this contact was made by means of a pencil of retort-carbon‖ or graphite, with others by means of an iron wire. Two glass tubes filled with metal were placed vertically side by side. At the hotter (upper) point of junction the platinum wires were melted together outside the tubes by means of the oxy-hydrogen blowpipe. So far as the wires which serve to make contact with the fluid metal at the hottest and coolest points penetrate the ends of the tubes, uniformity of temperature must be maintained. The cooler (lower) ends of the tubes were plunged into two concentric vessels full of mercury, which were placed in a bath of constant temperature, though not always the temperature of the room. From these mercury vessels wires of lead conducted to a petroleum bath of the temperature of the room, from which the copper connections were made. The leaden wires of course could not be placed directly in contact with the mercury. Their ends were melted into a glass tube, through the lower closed end of which a short platinum wire passed. I pass over here the precautions found necessary in order to ensure that the other portions of the circuit should be affected only by slight thermoelectric forces, which remained constant for a considerable time and which were separately determined. The electromotive forces were measured by compensation.

6. The temperature of the hotter point of contact was maintained:—(1) In a bath of mineral oil of high boiling-point, which was kept agitated by a stirrer. In this way a temperature of about 380° C. could be obtained. (2) In an air-bath, consisting of three concentric iron cylinders, surrounded on the outside by a jacket of iron and chamotte, which was constructed according to my designs for another investigation, and which Ehrhardt* has recently described. It was heated by means of gas, and permitted the attainment of a temperature of 580°. (3) By a brisk current of vapour of constant boiling-point, sent through a glass vessel protected against external radiation of heat. The substances employed were alcohol 80° C., water, xylol 140·5° C., aniline 183° C., dimethylaniline 192° C., toluidine 198° C., xylidine 214° C. In order to decide with certainty particular questions I required constant temperatures, not differing much from each other. For the control of other measurements, I further employed baths of vapour of benzoic acid 250° C., mercuric iodide 357° C., and sulphur 448° C. For still higher temperatures (up to 980° C.) I employed (4) a muffle. The vessels which contained the metal were of earthenware. Imagine an earthenware tube inclined some 10° to the horizontal plane, and provided at both ends with vertical pipe-heads. Two such tubes of equal length were placed side by side. Each contained a molten metal. The upper pipe-heads were within the muffle, and heated to a higher temperature than the lower ones. They were connected by a bridge of thick iron wire or of retort-carbon, by means of which a wide thick-walled chamotte-neck passed from the muffle through the heating-channel outwards, through which the earthenware tubes passed; the other two pipe heads were outside the muffle, surrounded by an iron box, which was heated by coal. The temperature then was maintained as close as possible to the melting point of the more difficultly fusible metal. In order to carry the circuit from the molten metal outside the muffle, previous experience had shown lead to be the only available metal which permitted the reduction of temperature to that of the room. The following arrangement was adopted in view of its properties:—At the lower end of a thin walled brass tube of about 12mm. diameter an iron tube was brazed; it was closed below by an iron disc screwed on, to the inside of which a piece of platinum foil was soldered. The screw closed against the molten metal in which the iron tube plunged. A platinum wire was in contact with the platinum foil. This was melted through the closed lower end of a glass tube. The bottom of this was filled to a height of about 10 mm. with graphite. Lead wire was pushed slowly into the glass tube, which melted and formed a continuous connection from the molten to the solid lead. The solid lead wire conducts again to points at the temperature of the room. All the different conductors (iron, platinum, and graphite) were completely surrounded by the molten metal in the pipe-head, which stood some 4 cm. above the top of the graphite layer. We may therefore assume equality of temperature in all. This last-described arrangement was employed for the circuits PbSn and SnBi.

7. I pass now to the results obtained. If we take the temperatures as abscissæ and the electromotive forces as ordinates, the following results are obtained. Most, if not all, the curves are not actually straight lines; they are of such a form that the centre of curvature lies on the side of the curve turned away from the axis of abscissæ, *i.e.*, the electromotive forces increase more rapidly than corresponds to proportionality with the temperature. Only the curve for NaHg, which is almost straight for a considerable distance, seems at higher temperatures to assume a curvature towards the other side. The thermoelectric force of this element is, however, so small that measurements with it offered special

* That we may regard the Peltierian heat as the equivalent of the work which the electricity does in passing to a lower potential-level at the points of contact, requires no justification. The work lost at the one contact-point can be restored by the equal amount gained at the other, just as the quantities of work in the portions of the two arms of a siphon at equal heights compensate each other. We cannot conclude anything, as Maxwell has done, as to the difference of potential produced, as a result of contact-electricity, from the Peltierian heat at the point of contact of two conductors.

† Alloy liquid at ordinary temperatures; about 1 eq. K to 1 eq. Na.

‡ Alloy liquid at ordinary temperatures; 1 part lead, 1 part bismuth, 3 parts mercury.

§ I wish here to express my obligations to the Royal Saxon Porcelain Manufactory, and especially to M. Büttner, for the great trouble which they have taken in the very difficult manufacture of these vessels.

‖ Platinum at 200° is amalgamated by mercury, and at about 500° is dissolved as energetically by mercury as it would be by boiling aqua regia.

* Wied. *Ann.* vol. xxiv. p. 217 (1885).

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difficulties. KHg is almost a straight line, but possesses certain peculiarities (see below).

The curves are certainly not of the second degree, but of the third at least. Tait's assumption that specific heat of electricity is proportional to the absolute temperature, which would lead to the equation to a parabola, therefore does not hold good for molten metals. I give here a few numbers from the curve for the element PbHg. It is

TABLE I.

Lead-Mercury.

	θ	ρ.	$\frac{de}{d\theta}$		Π calculated.
			Observed.	Calculated.	
20° C.	293	0	3·4	...	46·2
100	373	340	4·8	...	13·0
200	473	920	7·0	6·5	153·7
300	573	1710	9·2	8·3	244·6
400	673	2640	10·2	10·0	318·5
500	773	3750	12·5	11·8	448·3
580	853	4940	19·0	13·2	751·9

of especial interest, on account of the property of lead, not to give any Thomson effect. The first column gives the temperature of the warmer point of contact in centigrade degrees, the second the same reckoned from absolute zero. The temperature of the other point of contact is throughout 20° C. The third column contains the electromotive force e in micro-volts. If e is a function of θ, represented by a curve of the second degree, then $\frac{de}{d\theta}$ ought to be a linear function of θ. The fourth column shows the observed valne of $\frac{de}{d\theta}$, and the fifth the value calculated from the first two numbers of the fourth column. The differences are far greater than possible errors of observation. The last column gives the quantities of heat in gramme-calories which result at the point of contact of absolute temperature θ, when the quantity of electricity electro-chemically equivalent to 2 grammes hydrogen (193,000 coulombs) passes through.

If we conclude from the experiments of Le Roux (who, however, gives no absolute value of the Thomson effect) that there is no Thomson effect in lead, there must be such in mercury. Moreover its magnitude must be considerable. This follows from the observations with the couples HgCu, HgPt, HgFe, whose electromotive force I have measured for considerable differences of temperature. The Thomson effect is very considerable in the metals Cu, Pt, Fe; in mercury it must be at least of equal magnitude according to the results of these measurements.

The wires employed of the three metals when heated in the middle, whilst the ends were maintained at constant temperature, gave very considerable electromotive forces (70 to 200 microvolts) even after they had been repeatedly heated. Mercury, on the other hand, as is well known, gives none. This last phenomenon and the Thomson effect cannot therefore stand in any direct connection.

In the thermo-element PbHg, the contact points may have the respective absolute temperatures Θ and θ ($\Theta > \theta$); it may be supposed to remain closed so long that its thermo current has conveyed the electro-chemical unit of electricity through it. Then at the temperature Θ the quantity of heat Π_Θ is absorbed, and at θ the quantity of heat Π_θ is given off to surrounding objects. The difference $\Pi_\Theta - \Pi_\theta$ in the present example cannot be completely converted into electrical energy (with an oppositely bent curve it would not be the only equivalent), but there would be also heat from the interior of the metals themselves converted into work.

The following Table II. gives for different intervals of temperature the heat $\Pi_\Theta - \Pi_\theta$ in gramme-calories. Further, the electrical work L in the same units. The result is that in the most favourable case 47 per cent. of the heat $\Pi_\Theta - \Pi_\theta$ appears as useful electrical work. The remainder, at least 53 per cent., remains in the metals themselves, in the form of (reversible) heat. It is given in the fourth column.

The thermopile absorbs the quantity of heat Π_Θ at the highest temperature Θ; at least, the pile works with this heat-capital. How much of this heat appears as useful work? The sixth column shows that it is at the outside 40 per cent. If of the quantity of heat Π_Θ the whole remainder not converted into work at the temperature θ were given off, the fraction $\frac{\Theta - \theta}{\Theta}$ must be converted into current energy. The next column shows this fraction.

TABLE II.

Temp. interval.	$\Pi_\Theta - \Pi_\theta$.	Elec. work, L.	$\Pi_\Theta - \Pi_\theta - L$, or Heat in metals.	$\frac{L}{\Pi_\Theta - \Pi_\theta}$	$\frac{L}{\Pi_\Theta}$	$\frac{\Theta - \theta}{\Theta}$	$\frac{\Pi_\Theta - \Pi_\theta}{\Pi_\Theta}$
20–100	36·8	15·8	21·0	0·43	0·19	0·21	0·44
20–200	107·5	42·7	64·8	0·40	0·28	0·38	0·70
20–300	198·4	79·4	119·0	0·40	0·32	0·49	0·81
20–400	272·3	128·5	149·8	0·47	0·40	0·56	0·85
20–500	402·1	174·0	228·1	0·43	0·39	0·62	0·89
20–600	705·7	229·2	476·5	0·32	0·30	0·66	0·94

If we now enquire whether thermo elements are suitable arrangements for converting heat into work, we obtain the following result:—Elements for which the electromotive force increases greatly with rise of temperature, as is the case for the element HgPb, work with very small useful effect (not regarding the loss of heat by conduction, radiation, &c.). Thermo elements whose electromotive force decreases with rise of temperature work with more useful effect, but contribute absolutely less towards the work to be done.

Other elements with liquid metals give essentially the same results as the PbHg element. The curve for Hg(Hg + Br + Pb) has nearly the same form. In this combination both constituents are fluid at ordinary temperatures: I have examined them for an interval of more than 500°. It appeared to me of particular interest to repeat Magnus's experiment with this fluid alloy. If a portion of the amalgam was plunged cold into the rest heated to about 300°, no thermo-current was produced the electromotive force of which exceeded 0·5 microvolts, which was the lowest I was in a position to measure.

The curve for this element shows a remarkable peculiarity. At 180° it is convex towards the axis of abscissæ, but between 180° and 210° it becomes concave, and then again convex. In this respect it is qualitatively exactly like the curve which platinum-iron elements give, only that in the latter the peculiarity is more decided. With a PtFe element the curve rises steeply to about 360° and somewhat concave towards the axis of abscissæ, then bends rapidly towards the horizontal direction, having a maximum at 420°, then falls from this very little (almost horizontal) to a minimum at 520°, rises then slowly, and then from about 630° ascends again to 1,000° as steeply as from 0° to 36°.

The element consisting of molten potossium and mercury shows an exactly similar behaviour, the curve rising with oscillations. Consistent results are, however, only obtained with this latter element when vapours of constant boiling-point are employed as source of heat. Using the oil-bath or the air-bath, the values obtained at the same temperature often vary considerably.

We shall probably only be able to explain these phenomena by the assumption that molecular transformations take place also in liquid bodies (as is known to be the case, for example, with sulphur); and these changes appear, at least as far as their velocity is concerned, to depend on the rate of heating. The question then suggests itself whether molten cadmium, which in the form of vapour is monatomic, combined with a thermo-element with the similarly constituted mercury, would show linear dependence of electromotive force upon temperature.

The interval of temperature available seemed to be too small to determine this point with certainty; and I considered it beside the mark to employ cadmium amalgam, since we could no longer assume the existence of isolated atoms.

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8. Taking all the results together, we may come to the conclusion that in thermoelectricity we are still further from an insight into the true nature of things than most physicists have supposed. We must assume the existence of electromotive forces even in the interior of molten metals of unequal temperature; and, moreover, these follow no simple laws. It would not be difficult to find formulæ for the electromotive forces supposed to exist in the interior of metals which should satisfy the observations; but it seems to me that we do not thereby come nearer to a representation of the processes which occur. We may say with certainty that fluid unequally heated metals are electrically charged, and that by simple inequalities of temperature in a conductor the conditions for transformation of heat into work are fulfilled, only that we cannot obtain the work in the convenient form of a closed current. Perhaps this excitation of electricity takes place in all fluids, and generally in all substances, *i.e.*, also in the so-called vacuum; and the further question, important in principle, may arise, what influence this hitherto disregarded circumstance has upon physical processes.

If we return to the facts detailed above, everything indicates that thermoelectric excitement is an intermolecular process dependent upon the number or arrangement of atoms in the molecule. It is thus suggested that all the rough mechanical changes, which exert so much influence on the thermoelectric behaviour of a solid body, and which consist in drawing, bending, hardening, annealing, &c., are also connected with intermolecular, and thus in a measure chemical, changes. This would be in harmony with the one already known fact, that in steel, upon passage from the soft into the hard condition and *vice versâ* (also by simple drawing), the quantity of chemically combined carbon changes. Hard and soft steel give, as is well known, a tolerably powerful thermoelectric action.

CITY AND GUILDS OF LONDON INSTITUTE.

22C.—Electrical Instrument Making.

INSTRUCTIONS.—This examination is for the purpose of ascertaining whether the candidate has intelligently noted the methods employed in the workshop in the construction of electrical apparatus, and whether he has endeavoured to ascertain the scientific reasons for the processes followed. The candidate must confine himself to one grade only, the ordinary or honours, and must state at the top of his paper of answers which grade he has selected. He must not answer questions in more than one grade. If he has already passed in this subject, in the first class of the ordinary grade, he must select his questions from those of the honours grade. The number of the question must be placed before the answer in the worked paper. Three hours allowed for this paper.

ORDINARY GRADE.—[Candidates are not to answer more than two out of the first three questions, and not more than seven altogether.]

1. Explain exactly what is meant by saying that the electric resistance of a given wire is constant for the same temperature, and independent of the current passing through the wire.

2. A battery is sending a current through a wire; if this wire be gradually made shorter and shorter, describe what changes will take place (1) in the current, (2) in the potential difference at the terminals of the battery, and (3) in its electromotive force.

3. Define fully an ampere, an ohm, and a volt. What current will 15 cells, each having an E.M.F. of 1·07 volt and an internal resistance of 0·7 ohm, send through an electro-magnet having 28 ohms resistance, when the electro-magnet is shunted with a wire having 7 ohms resistance?

4. Give a description, with drawings, of a high resistance astatic reflecting galvanometer, with high insulation in all parts.

5. Give a description, with drawings, of the construction of a differential galvanometer. Describe fully the mode of adjusting the two coils, so that they may have equal resistance, and also equal magnetic effect.

6. Describe, with detailed drawings, the best form of "influence machine" with which you are acquainted, and explain the principle of its action.

7. How would you make a cheap resistance, the magnitude of which could be altered at will, to be used for strong currents? Give a drawing of the details, and a specification for the guidance of the maker.

8. Write out a specification of a good form of cheap electric trembling bell. What kind of cells would you use for bells, and why?

9. What are the conditions to be fulfilled in a key to be used with a Wheatstone bridge? Describe fully a simple form of key fulfilling these conditions.

10. Describe, in detail, the construction of a permanent magnet, mentioning the brand of steel to be used, and the country from which it should be obtained, the size and shape of the piece of steel employed, the mode of hardening, tempering, and of magnetising.

11. Explain the various shapes it would be desirable to give to the pole pieces of an electro-magnet, so as to obtain the maximum effect in various cases. State fully under what circumstances you would adopt each shape.

12. Give a drawing of a shunt box having high insulation. Prove what should be the resistance of three shunts, so that 1-10th, 1-100th, and 1,1,000th of the total current will pass through a galvanometer of 8,600 ohms resistance. What kind of wire would you use for the shunts, how would you wind it, and where would you place it to diminish the temperature error as much as possible?

13. In the construction of resistance boxes, what should be the relative diameters of the wires used in making the 1 ohm and the 1,000 ohm coils? Give full reasons for your answer.

14. Describe, with drawings, a telephone transmitter and receiver. Explain fully why an induction coil should be used with the transmitter when the length of the telephone line is considerable.

15. Give a drawing of a good switch for an incandescent lamp, and mention what are the characteristics of a good switch for this purpose.

16. You are required to solder together two copper wires in a galvanometer. What flux would you use and why? Give a sketch of the joint you would make, 1st, if the copper wires were thin, 2nd, if they were stout wires.

17. Two electro-magnets having iron cores and bobbins of exactly the same size and shape are wound, the one with a copper wire 0·01in. diameter, the other with a wire 0·02in. diameter, so that the external dimensions of the bobbins, when wound, are also the same in both cases. Calculate the relative strengths of the currents required to be used, so that the strength of the two electro-magnets may be the same.

HONOURS GRADE.—[Candidates are not to answer more than one out of the first three questions, and not more than seven altogether.]

1. Explain exactly what is meant by saying that the electric resistance of a given wire is constant for the same temperature, and independent of the current passing through the wire.

2. A battery is sending a current through a wire; if this wire be gradually made shorter and shorter, describe what changes will take place (1) in the current, (2) in the potential difference at the terminals of the battery, and (3) in its electromotive force.

3. Define fully an ampere, an ohm, and a volt. What current will 15 cells, each having an E.M.F. of 1·07 volt and an internal resistance of 0·7 ohm send through an electro-magnet having 28 ohms resistance, when the electro-magnet is shunted with a wire having 7 ohms resistance.

4. Describe, in detail, giving sketches, some form of apparatus especially adapted for measuring small resistances, and prove the formula employed in using the instrument.

5. Describe, in detail, giving sketches, an apparatus which may be used for measuring, with one observation, a resistance when a strong current is passing through the resistance, and show exactly how it is employed when used to measure the resistance of the electric arc.

6. Describe the theory and practical construction of a "constant current shunt," that is, one which shunts the current passing through the coils of a galvanometer, without altering the total current flowing in the circuit. Give an actual example of the numerical working out of the proper values to give to the coils of a constant current shunt.

7. Give a detailed account of some instrument used for measuring large currents in amperes, and of some instrument for measuring large potential differences in volts. Explain fully why a change of temperature may seriously affect the sensibility of the latter, while it produces, practically, no variation in the sensibility of the former.

8. Give an account, together with detailed sketches, of the apparatus employed in duplex signalling on a long submarine cable.

9. A horseshoe electro-magnet has two bobbins, each 2in. long and ⅞in. external diameter. If the diameter of the iron core is ¼in., the resistance of the remainder of the circuit 420 ohms, and the resistance of a cubic inch of pure copper 0·63 microhm, what should be the diameter of a copper wire having 94 per cent. of the conductivity of pure copper, to be wound on the electro-magnet, if the thickness of the silk be neglected? In what sort of way would you modify your answer to allow for the space occupied by the insulating covering?

10. Give a description, with detailed sketches, of a non-sparking key.

11. Certain specimens of soft iron, to be used for the cores of electro-magnets, are given you to examine. Describe, in detail, the kind of tests you would make to ascertain which specimen of iron was the most suitable for the purpose.

12. Describe, in detail, the mode of absolutely calibrating a current meter without the employment of any standard current meter.

13. Describe, in detail, the mode of absolutely calibrating a potential difference galvanometer, without the employment of any standard potential difference meter.

14. Calculate the size of plates that must be separated by a layer of air 0·01 inch in thickness, so that the air condenser may have 0·0001 of a microfarad capacity. One farad corresponds with about 10^{12} C. G. S. electrostatic units of capacity. About how much per cent. would your answer be altered if the air were replaced with paraffin wax?

15. Give a full description, with drawings, of a reflecting galvanometer for measuring capacity. What are the essential features of such a galvanometer?

LEGAL.

Re the Companies Act and in re the Brazilian Submarine Telegraph Company.

This was an appeal before Mr. Justice Grove and Mr. Justice Denman from an order made by Mr. Justice Mathew at Chambers, under sec. 35 of the Companies Act, 1862, by which a remedy is provided for the rectification of any improper entry or the omission of any entry in the register of the members of any company. The facts in the case were shortly as follow:—Madame Chatenay, of Rio, was at the time of her death the registered holder of 50 shares in the Brazilian Submarine Telegraph Com-

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pany. After her death in 1881, her son, Mr. Emilio Chatenay, instructed a Mr. Broe, resident in this country, to obtain letters of administration for him to his mother's estate. He sent Mr. Broe a power of attorney in Portuguese, by which, as appeared from the translation, he (Mr. Broe) was "especially to buy and sell shares of public companies and receive any dividends and to give receipts in conformity with his (Mr. Chatenay's) instructions." Mr. Broe sold the 50 shares in the usual way on the London Stock Exchange, and the transfers were signed by him in the name of Chatenay under the power of attorney which he held. Mr. Chatenay now denied that Mr. Broe had had any authority to execute the transfers, and he called upon the company to rectify their register by restoring his name to it as the holder of the 50 shares. They having refused to do so he had taken out a summons under section 35 of the Companies Act, 1862, which is as follows:—"If the name of any person is without sufficient caused entered in or omitted from the register of members of any company under this Act, he may, by motion in any of Her Majesty's superior courts of law or equity, or by application to a judge sitting in chambers, apply for an order of the Court that the register may be rectified; and the Court may either refuse such application . . or it may, if satisfied of the justice of the case, make an order for the rectification of the register and may direct the company to pay all the costs of such motion and any damages the party aggrieved may have sustained; the Court may in any proceeding under this section decide on any question relating to the title of any person who is a party to such proceeding to have his name entered in or omitted from the register, whether such question arises between two or more members or alleged members or between any members or alleged members and the company, and generally the Court may in any such proceeding decide any question that it may be necessary or expedient to decide for the rectification of the register; provided that the Court, if a Court of common law, may direct an issue to be tried." Mr. Justice Mathew, confirming an order of a master, directed an issue to be tried between Mr. Chatenay and the company, and the latter appealed against that order.

Mr. FINLAY, Q.C. (with whom was Mr. E. B. Calvert), for the company, contended that they ought not to be forced, as they were by the order, to fight an issue in which they had no interest. Mr. Chateney sought to affirm the transfers to himself executed by Mr. Broe, and disaffirm the transfers to the holders of the 50 shares executed on his behalf by Mr. Broe as his duly authorised agent. He said that Mr. Broe had no instructions either to accept or execute transfers, and that the English translation of the power of attorney which had been given by him to Mr. Broe was incorrect. The company did not object to the trial of an issue as to the registration of the 50 shares that had belonged to Mr. Chatenay, but they contended that it should be between him and the transferees. He (the learned counsel) did not contend that Mr. Justice Mathew had not had discretion to make the order, but he submitted that his discretion ought to be overruled, as the company ought not to be made the defendants in the issue.

Mr. Justice DENMAN asked if it was not more convenient that the issue should be tried than that the company should not be made defendants in an action.

Mr. FINLAY said if there were an action an order would be made bringing in the transferees as third parties to it. If the company were made defendants in an action they would have a right to claim an indemnity from Mr. Broe for having furnished them, if he had done so, with an incorrect translation of his power of attorney. It was his duty not to have misled them, and so caused them to register the transferees of Mr. Chatenay's shares. In an action brought in the Chancery Division by the Rio de Janeiro Gas Company against Mr. Chateney, where the question was as to the validity of the transfer of certain shares in that company under similar circumstances, a summons had been taken out by him (Mr. Chateney) in the Queen's Bench Division. This had been transferred to the Chancery Division, and there the Court directed an issue to try the question whether the shares were lawfully transferred, whether the transferee from Mr. Broe or Mr. Emilio Chatenay was the owner of the shares in question, and whether Mr. Chatenay was entitled to be on the register in respect of such shares; and the defendants were to have the same right as regards discovery as if an action had been brought by Mr. Emilio Chatenay against the said company and Mr. Oxley, the transferee. The learned counsel submitted that a similar order ought now to be made in this case. It was the more important to bring in the transferees at the trial of the issue, as, if it were decided in Mr. Chatenay's favour, that would not decide the question as between the transferees of the shares and the company. The transferees ought, as he contended, to have liberty to attend the trial and cross-examine the witnesses, but should be bound by the result. At any rate, the trial of the issue should be stayed until the question as between Mr. Chatenay and the transferees of his shares had been decided.

Mr. Gainsford Bruce, Q.C. (with whom was Mr. H. D. Greene), appeared for Mr. Chatenay, but was not called upon to argue the case.

The Court dismissed the appeal, holding that upon the whole of the facts the trial of an issue was the best mode of deciding the question in the case, as it was clearly distinguishable from one in which two persons set up a claim against each other to be placed on the register of a company. It was just possible that the defendant company might have placed the names of the transferees of Mr. Chatenay's shares on their register without proper authority, and that question ought first to be decided. The matter was still left open to the company in the sense of their being able to bind those persons whose names were actually on their register as the owners of the 50 shares. In order that the company (the defendants in the issue) should be in the same position as if an action had been brought, Mr. Justice Mathew had reserved to them all their rights. Appeal accordingly dismissed, with costs.

COMPANIES' MEETINGS.

Provincial (Brush) Electric Light and Power Co.

An extraordinary general meeting of the shareholders of this Company was held at 68A, Cow Cross-street, E.C., on the 11th inst., under the presidency of Mr. T. Fry, to consider the following resolutions:—

"(1) That the Company be wound up voluntarily, and that Mr. William Henry Pannell, of 38, Basinghall-street, London, chartered accountant, be appointed liquidator for the purposes of such winding-up. (2) That the shares held by the above-named Company in the Consolidated Electric Company (Limited), under an agreement dated the 9th day of March, 1883, and made between Joseph Samuel Beeman of the first part, William Taylor of the second part, Frank King of the third part, the South-Eastern (Brush) Electric Light and Power Company (Limited) of the fourth part, the Provincial (Brush) Electric Light and Power Company (Limited) of the fifth part, and the Consolidated Electric Company (Limited) of the sixth part, be not sold, but distributed among the shareholders in the above-named Company, share for share. Provided always that no shareholder in the above-named Company who shall be in arrear with respect to payment of calls shall be entitled to receive such shares until all such arrears shall be paid, but that such shares shall be held by the liquidator in the meantime, and if such arrears be not paid within a reasonable time, shall be sold by him as though this resolution had not been passed. (3) That the liquidator be requested, authorised, and empowered to carry out the said resolution."

The SECRETARY read the notice convening the meeting as above.

The CHAIRMAN said: Gentlemen, we ask you to-day to accept the inevitable. We have long seen—as many of the shareholders have—that being deprived of the means of carrying on a business which might have become profitable, the end must sooner or later arrive. The only difference between us was this—when we should terminate the existence of the Company. I think that we, sitting on this side of the table, and having a complete knowledge of the inner life of the Company are better able to judge when we shall bring it to a close than those who have not had the same opportunity. Since we met in January very much has been done to improve our prospects, especially in connection with the Consolidated Company, and we now see that we can terminate the existence of the Company and still preserve something to the shareholders. He concluded by proposing the first resolution.

Mr. WAPSHARE seconded the resolution.

Mr. J. B. BRAITHWAITE asked whether the Chairman had considered the suggestion made on behalf of the majority of the shareholders, namely, that Mr. Stewart should be joined with Mr. Pannell as co-liquidator.

The CHAIRMAN stated that the Directors were not aware of any suggestions which had been made on behalf of the majority of the shareholders.

Mr. BRAITHWAITE asserted that at the last meeting he and those with whom he was acting polled two to one. He wished, at all events, to know whether the Directors would accede to the demand that the shareholders should be represented on the liquidation.

The CHAIRMAN replied in the negative, and stated that they had been advised that they could not. They gave the shareholders an opportunity when the liquidation was first talked of of joining with them—that was one Director and Mr. Stewart; but behind their backs an attempt was made to appoint two shareholders to wind up the Company, instead of one Director and one shareholder. To avoid any complication of that kind on the present occasion they determined that the matter should be left to some one entirely independent of the Company, and surely the matter might be left to Mr. Pannell.

Mr. BRAITHWAITE said that he and his friends had done all that they could in the past to put a stop to the reckless extravagance and waste of their money, and they had received great support from the shareholders. Notwithstanding that fact, they had heard the distinct avowal of the Chairman that he would not allow the shareholders to be represented on the liquidation, especially with such Directors as they had had, whose past conduct could not, he maintained, be considered free from blame. He therefore moved an amendment to the effect that the Company be wound up voluntarily, leaving the question of the appointment of liquidators to a separate resolution, or even to a subsequent meeting. He thought it would be most suicidal to entrust to the nominee of the Directors the whole of the carrying out of the liquidation, which would give to that gentleman full powers to call up the whole of the remaining capital, and to quash all matters connected with the Consolidated Company, the history of the formation of which was, he said, still involved in great obscurity. It was only fair that the shareholders should be represented on the liquidation, and they proposed that Mr. C. H. Stewart, a member of the Corporation, and a gentleman of high position, should be appointed for that purpose to act with the gentleman nominated by the Directors.

Mr. BURT (the solicitor) said he had been obliged to advise the Chairman that, as a matter of law, it was impossible to alter the resolution or put any amendment to it. The meeting could only pass it or reject it.

Mr. BRAITHWAITE stated that he had been advised that his amendment was perfectly in order, and that the course he suggested had been acted upon on several occasions.

Mr. BROOKER seconded the amendment.

The CHAIRMAN said they had heard that he could not put the amendment. [A Voice: "Another shuffle."] The Directors did not desire to have anything to do with the liquidation. They were acting, as they believed, in the interests of all, and they drew no distinction between those shareholders who were supporting them and those who were in favour of Mr. Braithwaite. All that they desired was to save as much as they could for the Company; and in time they might possibly—if the Consolidated Company prospered as he believed it would—get a very con-

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siderable return. For their present purposes, however, they wanted to wind up, and as quickly and cheaply as possible; and by employing Mr. Pannell the matter would be left in the hands of one man, whose experience would enable him to deal with the assets of the company and turn them to the very best account, and no time would be wasted in conferring with other liquidators. He declined to put the amendment, as no notice had been given of it.

Mr. BRAITHWAITE said, in face of the ruling of the Chairman, he would move the adjournment of the meeting for a fortnight, in order to give the necessary notice.

Mr. BROOKER seconded the motion.

The CHAIRMAN put the resolution, and announced that there were 11 for it and three or four against it; but he would now demand a poll.

Mr. BRAITHWAITE said that there were 11 for his motion and three against it, two of whom were Directors, and yet the Chairman demanded a poll, knowing that he (the speaker) and his friends had not sent out any proxies.

[A VOICE: "Another shuffle".]

The CHAIRMAN said his desire was to save the shareholders time and trouble. He could tell the shareholders that it was perfectly impossible for Mr. Braithwaite to get a sufficient majority to wind-up the Company without the assistance of the Board. If things were brought to a deadlock, the Directors would have to go on with the business, and they could not do so without making calls. They had nothing whatever to conceal.

The poll was then taken, and

The CHAIRMAN stated that the result was as follows:—17 shareholders, holding 930 shares, had voted for Mr. Braithwaite's proposition, and 128 shareholders, holding 3,849 shares, had voted against it. That was including the proxies. He then put the original resolution, which was again lost on the show of hands, a poll being again demanded.

Mr. BRAITHWAITE said it was a farce to take the poll.

The CHAIRMAN stated that the result would be the same. He afterwards proposed the next resolution.

Mr. WAPSHARE having seconded the motion,

Mr. BRAITHWAITE said he was advised that if they accepted the shares of the Consolidated Company, as proposed, it would be useless for them to call in question any of the proceedings which led to the formation of that company, which, he said, was established without consulting the shareholders. It was very probable, if they had had a shareholders' nominee on the liquidation, he would have found circumstances in connection with the formation of the Consolidated Company which would have enabled him to withhold any balance due by them under the agreement with that company. He therefore moved an amendment to the effect that the liquidator should hold the shares of the Consolidated Company until the conclusion of the liquidation of the Company.

The CHAIRMAN said he should oppose the amendment, as no notice had been given.

Mr. BRAITHWAITE said that no opportunity had been given them to do so. His firm addressed a letter to the Chairman and Directors as to the appointment of Mr. Stewart, and though that letter was answered by Mr. Offor, they received no official reply on the part of the Directors until they came to that meeting.

In answer to Mr. STEWART,

The CHAIRMAN said there was still £1,800 outstanding of the amount they had undertaken to lend to the Consolidated Company. He would deline to put the amendment. He put the resolution, which was lost on the show of hands, a poll again being demanded. He afterwards put the third resolution, with the same result. The polls were taken subsequently, the resolutions being carried.

The South Eastern (Brush) Electric Light and Power Company (Limited).

An extraordinary general meeting of this Company was held on 11th inst. at the offices, 68A, Cowcross-street, E.C.

Mr. FRY (the chairman) presided, and said that in proposing the first resolution the Directors were simply doing what they had announced their intention to do, and what he believed the shareholders desired. They were aware that a committee of investigation was appointed, of which Mr. Stewart, Mr. Hewitt, and Mr. Rennie were members. Their report was not adopted, but at the same time the Directors pledged themselves that at the earliest possible moment that they thought desirable in the interests of the Company to terminate its existence they would do so. He was present to propose the first resolution: "That the Company be wound up voluntarily, and that Mr. William Henry Pannell, of 38, Basinghall-street, London, chartered accountant, be appointed liquidator for the purposes of such winding up." In asking Mr. Pannell to undertake the duties of liquidator the Directors desired to avoid any conflict between themselves as representing a very large number of shareholders and others, who also represented a considerable section of the shareholders. It was thought that if a Director were proposed, or two Directors, it might be open to objection, and as a certain section of the shareholders had put forward as their nominees two shareholders outside the Board, it was thought that the more dignified manner of disposing of the liquidation was to leave it to a man possessed of considerable experience and of high standing. He had therefore very great pleasure in recommending the resolution to their consideration.

Mr. WAPSHARE seconded the resolution.

Mr. J. B. BRAITHWAITE said that he and his firm, feeling that it was only right that some shareholder should be associated with Mr. Pannell in the liquidation of the Company, wrote to the Directors asking whether they would accept Mr. C. H. Stewart. To that communication they had received no official reply beyond a letter acknowledging its receipt, and he therefore now asked the Chairman whether the Directors were prepared to assent to the appointment of Mr. Stewart.

The CHAIRMAN: Certainly not.

Mr. BRAITHWAITE said that in that case he would move an amendment that the first resolution terminate at the word "voluntary."

The CHAIRMAN ruled, as in the previous meeting, that no amendment could be proposed.

Mr. BRAITHWAITE then moved the adjournment of the meeting.

The CHAIRMAN said that no good would be gained by adopting such a course, as at any adjournment only the business fixed for this meeting could be transacted, and again the present resolutions must either be accepted or rejected in their present form.

Mr. BRAITHWAITE thereupon withdrew his motion for adjournment, and after a long discussion of a personal nature the original motion was put to the meeting and lost on the show of hands.

A poll was demanded on behalf of the Directors, and it was at once proceeded with. The resolution was again lost on account of the requisite majority of three-fourths not having voted in its favour. The numbers were—For the resolution, 5,162 votes; against the resolution, 1,760 votes.

The CHAIRMAN said that the business of the Company would now have to be continued, and calls would have to be made.

In reply to a question, the CHAIRMAN said that he should decline to act as a liquidator with Mr. Pannell or Mr. Stewart, as he did not think that he had been properly treated by a certain section of the shareholders.

Mr. BRAITHWAITE said that it was his desire to see the Company liquidated as cheaply and as speedily as possible, and asked the Chairman if he would support a proposal, if it were made at another meeting, to appoint other liquidators than those suggested by the Directors.

The CHAIRMAN declined to give any promise, and repudiated any idea that Mr. Pannell was in any way the nominee of the Board.

After some further conversation the meeting broke up.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JUNE 10.		BUSINESS DONE WEEK ENDING JUNE 10. Highest.		Lowest.	
Anglo-American	28,	29	.....	—	.....	—
Do. Preferred	48,	49	.....	49½	.....	48½
Do. Deferred	7,	8	.....	8	.....	7⅞
Brazilian Submarine	11½,	11⅝	.....	11 7-16	.....	11½
Cuba	11½,	12	.....	11⅞	.....	11½
Do. Preference	18,	19	.....	—	.....	—
Direct Spanish	1½,	2	.....	—	.....	—
Do. Preference	11½,	12½	.....	11⅝	.....	—
Direct United States Cable	8¾,	9¼	.....	9⅛	.....	9
Eastern Telegraph	11½,	11⅝	.....	12	.....	11½
Do. 6 per Cent. Preference	13½,	14	.....	13⅞	.....	13⅝
Do. 5 per Cent. Debentures, 1899	104,	107	.....	107	.....	105½
Eastern Extension	12½,	12¾	.....	12 15-16	.....	12⅝
German Union	9½,	9⅝	.....	9¾	.....	9⅝
Globe Telegraph and Trust	7,	7½	.....	7 3-16	.....	7
Do. Preference	12⅞,	13⅛	.....	13⅛	.....	12⅞
Great Northern	14,	14½	.....	14⅝	.....	14
Indo-European	80½,	81½	.....	82	.....	81½
Reuter's	7½,	8	.....	—	.....	—
Submarine	180,	190	.....	181	.....	—
West India and Panama	¾,	1	.....	15-16	.....	¾
Do. 1st Preference	7⅞,	8¼	.....	8 3-16	.....	8*
Western Brazilian	6½,	6⅝	.....	6⅝	.....	6½
Western Union 7 per Cent. 1st Mortgage	117,	122	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	100,	103	.....	—	.....	—

* x.d. 6s. on account of arrears.

TELEPHONES.

Consolid. Telephone and Maintenance	⅝,	⅝	.....	½	.....	—
Oriental	⅛,	⅜	.....	—	.....	—
United Telephone	12,	12½	.....	12½	.....	11⅞

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	1⅞	.....	1 13-16	.....	1½
Do. (fully paid)	3,	3½	.....	3½	.....	—
Hammond Light (£3 15s. paid)	⅛,	⅜	.....	—	.....	—
Swan	¼,	½	.....	—	.....	—
Maxim-Weston	⅛,	¼	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	35½,	36½	.....	36½	.....	35¾
India Rubber, Gutta Percha, and Telegraph Works	24,	25	.....	24¾	.....	24

TRAFFIC RECEIPTS FOR MAY, 1885.

COMPANIES.	May, 1885.	May, 1884.	Increase.	Decrease.
Brazilian Submarine	—	—	—	—
Cuba Submarine	3,700	2,973	727	—
Direct Spanish Telegraph	1,345	1,552	—	207
Direct United States	—	—	—	—
Eastern Extension	50,016	41,708	8,308	—
Eastern Telegraph	61,327	51,537	9,790	—
Great Northern	—	—	—	—
Submarine	—	—	—	—
West Coast of America	3,800	—	—	—
Western and Brazilian	—	—	—	—

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THE INTERNATIONAL INVENTIONS EXHIBITION.

DYNAMO-ELECTRIC MACHINERY.

BY W. M. MORDEY.

Probably for the general public, and certainly for the electrical world, the electric lighting apparatus will prove to be the most interesting and important of all the displays at the Inventions Exhibition. Whatever other solid educational results the Exhibition may have, it cannot fail in impressing on the public the fact that electric lighting has now so far emerged from the experimental stage as to have fully entered on its career as a practical commercial branch of engineering. And, before all things, it is perhaps necessary to the extensive application of electricity in the immediate future that the public should be satisfied on this point, in order that the feeling of scepticism or uncertainty which is one of the barriers to house-to-house lighting may be removed. Many reasons have been given for the slow progress hitherto made in this country in the application of the electric light, and no doubt the causes of this slowness are very numerous and varied; but perhaps it has not been sufficiently recognised that the public are not yet educated up to the point of a confident belief in the possibility of successful electric lighting on a large scale. The attitude of the man who would not go into the water until he had learnt to swim is very like that of the public with regard to this matter. Until a town, or a considerable portion of a town, has been lighted by electricity, it may be said that it will be very difficult to get a town lighted electrically. But here in the Exhibition may be seen electric lighting, approaching in amount that necessary for a town district, successfully carried out under conditions that are distinctly unfavourable from the suppliers' point of view. It may not be too much to hope that this Exhibition will at least do a great deal to remove any prevalent feelings of uncertainty, and that visitors may be not only pleased and dazzled by all that electricians have to show them in the grounds and in the Exhibition buildings themselves, but that their minds may be fully opened to the solid commercial possibilities of this new department of engineering.

The first feeling produced in the mind of an observant visitor to the Exhibition, who is acquainted with the general principles of apparatus for the generation of electricity, will be one of some disappointment at the absence of anything at all approaching to a startling novelty; but a little consideration ought to convince him that this absence of new things is really a most hopeful sign, showing, as it does, that the construction of electrical machines has settled down into certain grooves which have been proved by experience to be the best; and that therefore the element of permanency has been introduced into the manufacture. It is not that inventors and scientists have been idle during the past year or two, for readers of contemporary scientific literature well know that a very great number of earnest workers have been, and are, engaged in the investigation of all questions relating to the application of electricity, and that no point has received more careful attention than the dynamo machine. It may therefore be taken for granted that if inventors have little or nothing new in principle to bring forward it is because they are satisfied that known types of machines contain in them the elements of the greatest attainable perfection, and that progress is not so much to be sought in the direction of new forms as in the careful study of old ones, with a view to the elimination, as far as possible, of all prejudicial actions and causes of loss. Thus it is to be noted that while few, if any, of the dynamo machines at work or on exhibition contain anything essentially new scientifically, many of them show that great attention has been given to all such points as render them capable of working economically and satisfactorily for long periods. The machines are for the most part well and soundly constructed mechanically. They are much less likely to break down or get out of order than was the case a year or two ago, while attention has been given to practical details, such as facilitate examination and repair, and enable the operations of taking to pieces or putting together to be easily carried on. The opportunity afforded of observing the working, as well as studying the construction, of the Thomson-Houston apparatus will be welcomed by English electricians, who have only hitherto been made acquainted with this system through the medium of the technical press; the machines now shown being, we believe, the first that have reached this side of the Atlantic. It is an interesting, and, perhaps, a significant fact that almost all American electric lighting inventions consist of "systems" more or less fully developed and self contained. If we glance at the principal importation of this class from the United States—the inventions of Edison, Brush, Maxim-Weston, Hochhausen, and now of Thomson-Houston—we see not a separate dynamo in one, and a new lamp in another, but a full set of apparatus worked out in all or most of the details necessary for actual installation; and including dynamos, methods of current or electromotive force regulation, lamps, cut outs, meters, conductors, and fittings. This attempted completeness, which is at least as striking in this the latest arrival as in any of the others, well illustrates the inventiveness of our American cousins; and shows, also, their keen practical commercial instinct.

While engaged in noting the general impressions produced on the mind by what is to be seen at the Exhibition, it may not be out of place to say a few words about some things that are conspicuous by their absence—some inventions that might have been expected to be shown. There is no doubt that for some time there has been "in the air" a sort of ill-defined idea that there was nothing permanent about the present principles employed in the construction of dynamos, and that some great discovery might be expected that would completely revolutionise existing methods, and enable electricity to be generated with great ease and vastly increased economy. Such expectations as these are no doubt inseparable from the existing general state of popular knowledge of electrical principles. At the same time it must be confessed that it is not only among the general public that these ideas are met with—there are recorded opinions expressed by one or two well known men which have perhaps been taken too literally, and a public accustomed to startling revelations of science, and especially of electrical science, has seized on them in its blind belief that nothing is impossible to science.

We have said that the absence from the Exhibition of anything very new in principle, or new in the application of an old and known principle, was rather a healthy sign than otherwise, because it tends to allay all feeling of expectation of the sort we have mentioned. If we try and trace these ideas back to their source we shall find—where they have any distinct form at all—that we are led in one direction to "unipolar" induction, and in another direction to thermo-electricity. With regard to "unipolar" induction—to employ the unfortunate and misleading term, of Continental origin, by which the magneto-electric induction of continuous currents, without commutation is known—it may be said at once, we think, that although the principle holds out a promise of practical use for certain purposes where low potential and large quantity are required, it is very unlikely that for other purposes than these it will ever meet with extensive application. But even if it be supposed for the sake of argument that machines may at some future time be constructed on the principle of "unipolar" induction, capable of producing high electromotive forces suitable for general employment, it would be easy to arrive at the conclusion that no great advance in economy of electrical production could result, since existing forms of generators now succeed in returning, as electrical energy, so large a proportion of the mechanical energy expended in them that further advance in this direction is practically impossible. We are well within the mark when we say that any fair commercial dynamo will account electrically for 90 per cent. of the power delivered to it, and will give 80 per cent. as a useful commercial return. It must therefore be evident that, as far as economy in the generation

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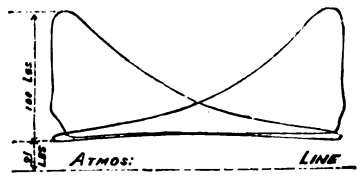
of electricity is concerned, when a steam engine or other source of motive power is relied on no further substantial improvement is possible in the electric generator. But no doubt the advocates of "unipolar" machines would say that, in the matter of the collection of the generated current, a machine without a commutator offers practical advantages over all ordinary commutating machines. This argument was freely advanced three or four years ago in support of alternate current dynamos, although in some of these machines the collection of the current does not appear to be very simple, being certainly not less troublesome than in many continuous current generators; while it is only necessary to examine the majority of the dynamos working in the shed, and elsewhere in the Exhibition, to be convinced that the difficulty of collecting even very large continuous currents has practically disappeared, little or nothing remaining for improvement in this direction, and that little being attainable by known means. Of course, in a "unipolar" dynamo the collection of any given current by some form of rubbing contact must always be less difficult than the collection of the same current from a commutated armature (assuming that the velocity at the contact is the same in the two cases), because in the latter, in addition to the electrical resistance and mechanical friction, there is a certain amount of difficulty produced by the act of commutation. But, seeing how small is the objection to ordinary dynamos on this ground, it is not likely, even if they could be made suitable in other ways, that in this matter of current collection "unipolar dynamos" can ever be expected to offer such great advantages as to lead to their extensive use. The trouble, such as it is, in these machines might be completely overcome by making use of stationary armatures and revolving field magnets, although it is probable that the great mass of the latter would stand in the way of such a solution of the question. So that on no sufficient ground is there reason to believe that any radical change in the principles of generating machines is in store for us.

But, while it is clear that no great improvement in this direction is to be looked for, it must not be forgotten that the dynamo is only one of the agents concerned in converting the heat energy of the coal into electrical energy, and that the great loss is in the steam generator and motor. The fact that so large a proportion of the energy of the fuel is lost has led to many attempts at various times to obtain electricity by the application of the principle discovered by Seebeck, that an electromotive force was produced by heating the contact junction of two dissimilar metals. And quite recently a fresh impetus has been given to the consideration of the subject, and a certain amount of rather wild anticipation has been indulged in by a portion of the public, as a result of some observations reported to have been made by Mr. Edison to some journalists by whom he was interviewed. From the newspaper paragraphs we learn that Mr. Edison is engaged in an attempt "to get electricity direct from the coal." This may reasonably be supposed to mean that he is trying to find a practical and satisfactory form of thermopile, capable of being used for the production of the large currents necessary in electric lighting and distribution of power. A great many attempts have been made in this direction; but never with any very good results. At the Health Exhibition last year a large thermopile was in course of construction in the dynamo shed, but it appears that it either was not completed, or was not found to act satisfactorily, as it was never exhibited; and no account of it, as far as we are aware, was published. The difficulties attending the construction of large thermopiles are apparently very great. The metals most suitable for the purpose are of high specific resistance, and the high temperature necessary to obtain good results, besides increasing the resistance, appears to render the maintenance of the junctions by no means an easy matter. The resistance can be reduced by increase of the cross section of the elements, but this is objectionable for several very good reasons. Until the elementary difficulties are overcome, it is almost unnecessary to inquire into the question of how far the problem of the economical employment of fuel can be solved by means of thermopiles; while it must be recognised that were the solution even as satisfactory as Mr. Edison could desire, it could not lead to results as regards efficiency surpassing the generation of electricity by dynamo machines driven by plentiful water power.

(To be continued.)

ENGINES.

Messrs. Robey and Co., of the Globe Works, Lincoln, exhibit two engines which they are desirous of introducing to the notice of electric light engineers. We are indebted to Messrs. Robey for the illustration of these machines. Fig. 1 shows one of their special semi-fixed compound engines, which they claim possess several advantages, and that they are most economical engines. In ordinary high-pressure engines the steam, after having done its work in propelling the piston to the end of its stroke, is discharged direct into the atmosphere, very often (especially in badly designed engines) at a considerable pressure, and, in consequence, a loss of power. For many years past attempts have been made to avoid the loss by passing the exhaust steam into a second cylinder of larger diameter, and then utilising its remaining energy, and as far



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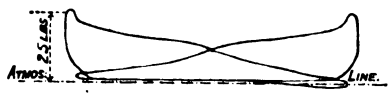
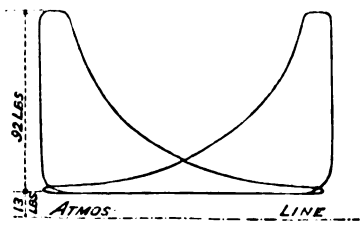


Scale 1/72.

Set C.—From an Engine 20 H.-P. nominal.

back as the year 1864 Robey and Co. constructed engines on this plan. Owing to improvements in their high pressure engines, the construction of compound engines was for a time discontinued. Of late, however, Robey and Co. have made such further improvements in the construction of compound



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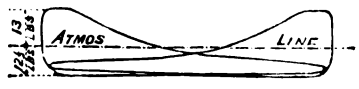

Scale 1/72.

Set D.--From an Engine 40 H.-P. nominal.

engines as to secure an economy of fuel rarely equalled in even the best class of condensing marine engines. Commencing with steam of at least 120lb. pressure, this is expanded in the two cylinders down to atmosphere pressure, being reheated on its way in an intermediate receiver of large capacity, thus avoiding the great loss between the two cylinders so often found in engines of the compound type.

Another point of great importance is the proper distribution of the steam between the high and low pressure cylinders, this being often so incorrectly done that the one cylinder acts as a brake upon the other, and a loss instead of saving is the

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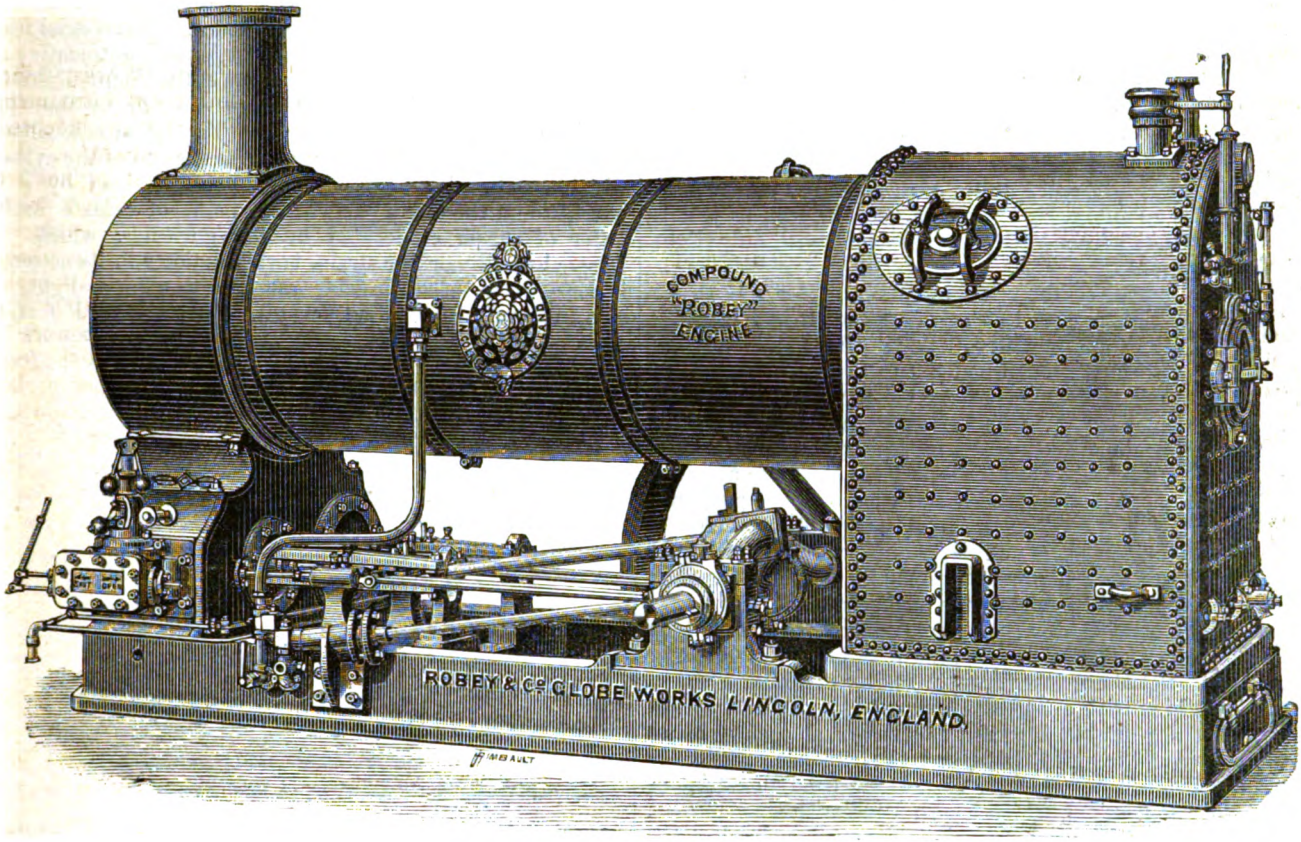
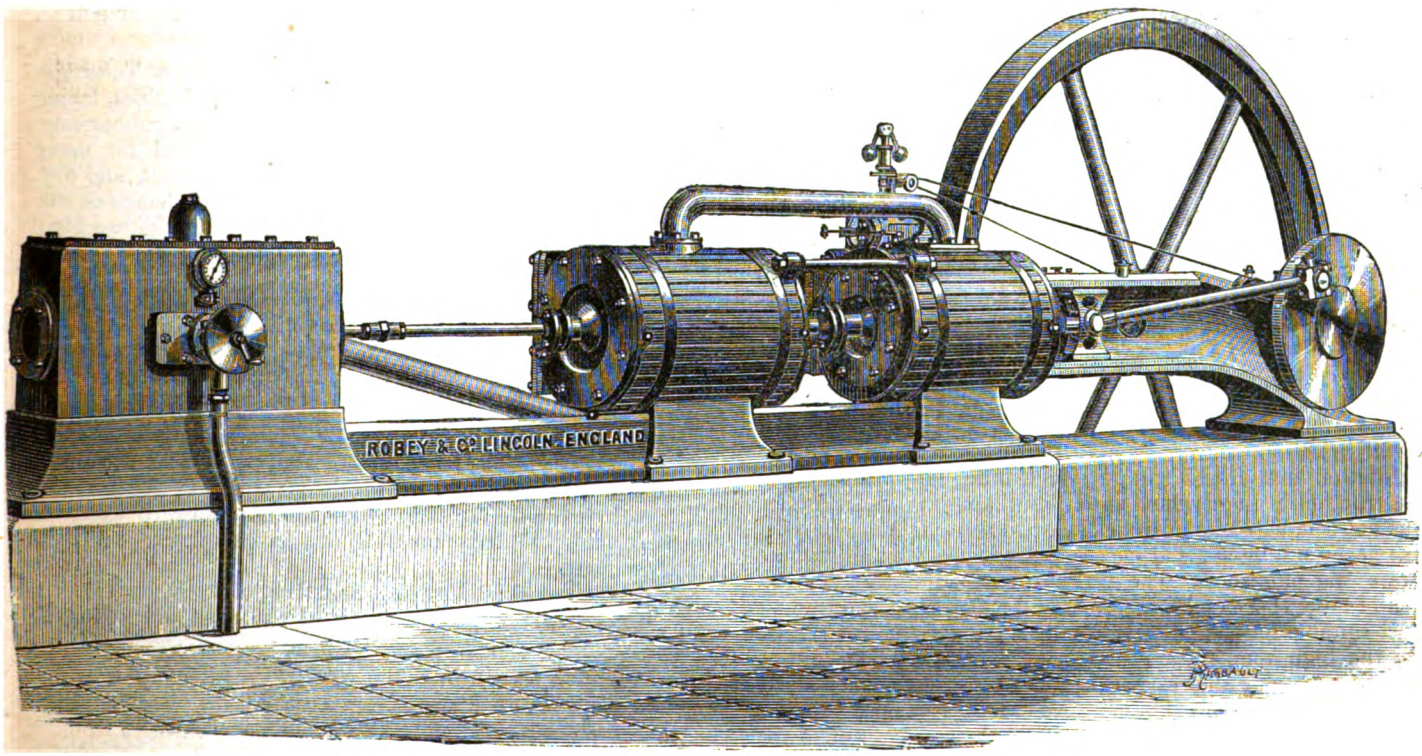
result. The valve gear in the Robey engine is arranged so that this loss can never take place. The working parts are arranged to be easily accessible for examination and adjustment, and the whole construction has been made so strong and simple that

the best point for an average load. The larger engines (*i.e.*, 25 horse-power and upwards) have independent cut-off valves, worked by separate excentrics, so that the ratio of expansion may be varied if required. The cylinders are steam-jacketed,



Robey's Semi-Fixed Compound Engine.



Robey's Fixed Compound Engine.

it can be worked with the same ease as any ordinary double cylinder engine. The smaller engines are arranged to work with one slide valve to each cylinder, with its cut-off fixed at

made of good hard metal, free from blowholes and other imperfections, and each is fitted with a metal lever made of specially hard, close-grained metal. The cylinders are provided

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with drain cocks to the end of each cylinder, as well as to the steam jacket, and additional cocks for taking off indicator diagrams. The main valve to high pressure cylinder is made of best gun metal.

The piston and valve rods are of steel, the valve rod joints have case-hardened pins, and the large sizes have adjustable cotters for taking up the wear. The stuffing boxes are all fitted with gun metal glands.

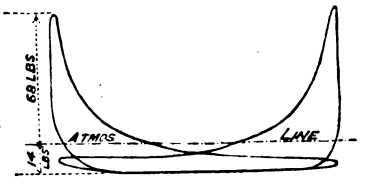
The crank shaft is of steel, forged solid, and the web slotted out, and each crank is supplied with balance weights, so as to accurately counterpoise the moving parts. The engine is fitted, when required, with a delicately-adjusted governor, controlling the cut-off valve of the high-pressure cylinder, the whole forming an automatic expansion gear, by which the cut-off can be regulated from $\frac{1}{8}$ to $\frac{5}{8}$ of the stroke with only slight variations in speed.

The main bearings are of gun metal and are adjustable in three directions. Lubricators are fitted to all working parts, specially constructed for long runs and suitable for electric lighting. The boiler tubes are arranged in vertical lines and with wide spaces to prevent the formation of scale upon them. The boilers are double riveted in all seams, and are made to stand a working pressure of 140lb. The corners of the firebox are made of large radius to admit of the mud hole plugs in the corners, and the mud hole plugs are so distributed that a scraper can be passed between each row of stays in a firebox shell. A series of carefully conducted tests shows that these improved compound engines will work with a consumption of less than 2lb. of Welsh coal per horse-power per hour when developing two and a half times their nominal power. The accompanying diagrams will explain themselves. Set C are taken from an engine of 20 horse-power nominal, working with a load of 54 horse-power indicated; the steam, entering the high-pressure cylinder at nearly boiler pressure, is expanded nine times, and the exhaust pressure is reduced to atmosphere pressure. Set D are from an engine of 40 horse-power nominal, which is also fitted with a condenser; the small consumption of fuel in this engine enables the exhaust draught in the chimney to be dispensed with.

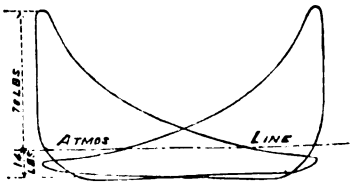
The speed arrangement, instead of being done in the ordinary manner by a speed governor driven by the engine, is controlled entirely by electricity, this giving it a special advantage in driving electric light installations. A portion of the current generated by the machine is used to excite the coils of the solenoid, which holds suspended within it an iron core, to one end of which is attached the end of the long arm of a lever, the short arm of which works upon a double beat Cornish valve, which regulates the admission of steam. The governor is arranged to maintain a constant current, or constant E.M.F., as may be required, and is so sensitive that the slightest change as it works is felt and responded to by the engineer.

When driving incandescent lamps with an ordinary shunt-wound machine, the lights may be varied to any extent within the limits of the power of the machine, without the slightest risk of injury to the lamps, the power developed by the engine and the speed of the machine depending entirely upon the amount of work done by it. In arc lighting this is very important, the speed of the machine being reduced within certain limits in almost exact ratio with the number of lamps turned out. It is well known that there is a special pressure of steam and point of cut-off which gives the best result in compound engines, and an engine which when developing, say, 20 horse-power may be a very economical motor, becomes extremely wasteful if called upon to develop 10 horse-power at the same speed, the steam being cut off at so early a point as to become expanded far below the atmosphere, thus converting the low pressure cylinder into a brake, whereas if this speed could be reduced to 10 revolutions the pressure and cut-off would remain constant, and every stroke of the engine would be delivered with the same economy as at the higher speed, while the wear and tear would of course only be one-fifth. This is exactly what is accomplished by the use of the electric regulator, and the greatest success has been attained by this apparatus in regular use.

Fig. 2 shows an improved horizontal fixed engine, with "Proell" automatic expansion gear, intended for large permanent installations. In such work it is important that great strength and solidity should be secured, and that regularity in running should be obtained. These important points are claimed for the engine here illustrated. It will be seen from the illustration that from the shape of the guides the engine is rigid in all directions, and has a most substantial base, both under the main bearing and the cylinder. The special feature of this engine is the arrangement of Dr. Proell's automatic expansion gear, which gave such good results at the Vienna Exhibition. The results obtained for this gear are superior to the Corliss gear, while the apparatus is simple. The steam is admitted by two Cornish equilibrium valves (one at the end of the cylinder), which are lifted so as to give a constant lead by a fixed excentric on the crank shaft. The point of release and the order of cut-off is decided by the governor, which, being relieved of all work or strain, is very delicate in its action, and is constructed to have a wide range with a very slight variation in speed. In the diagrams given below, Figs. F 1 and F 2



Scale 1/96.



Scale 1/96.

Figs. F 1 and F 2.—From an Engine 50 H.-P. nominal.

are taken from an engine of 50 h.-p. nominal, and range from 25 to 200 h.-p., the variations in speed being not more than one revolution of the engine. It will be seen that even with the very earliest cut-off, as little as 1-30th, the admission of steam is full and the cut-off as perfect as with a later point.

EAST ARCADE.

An exhibit to be noted is that of Henley's Telegraph Company, who show specimens of their make of cables, laying stress upon the value of their ozokerited india rubber core. Of this core we are told that "it has been boiled for many hours, it has been frozen, and made alternately wet and dry, hot and cold, without undergoing the slightest change or sustaining the least loss of insulation." There is also shown Henley's patent cast and wrought-iron troughing for underground conductors.

Close by, Callender's Bitumen Telegraph Company have an exhibit of their make of cables. There is nothing new to chronicle in the manufacture of these cables, but we may say that they have a fairly extensive and satisfactory use. We are inclined to think that in the near future the users of electric light leads will specify their wants, somewhat after the manner of the cable companies. They will have wire of a certain conductivity, and the insulation will also be specified. The various companies who exhibit are used to such specifications, and will have no difficulty in complying with the requirements.

Messrs. Thompson, Dowsing, and Rew, of 4, Queen Victoria-street, E.C., have a large number of excellent and well-made appliances on view, amongst which we noticed the following:—Dynamos, ammeters, and voltmeters, &c.; the Howell patent accumulator, with plates cut from a porous preparation of lead; Alexandra incandescent lamps, of a new shape; the Carré improved carbons, for arc lamps, batteries, telephones, &c.; terminals of all kinds, and a number of admirable specimens of their patent connected and single link chain leather belting, made with both oak and orange tanned leather. The latter is too well known to need description. Suffice it to say that it is perfectly adapted for the requirements of electric lighting.

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NOTES.

THE SPANISH TELEGRAPHS.—Telegraphic communication with Madrid has been delayed by heavy rains.

THE INSTALLATION AT WHITELEY'S.—This installation, which had but recently been put down, cost about £2,000.

EASTERN TELEGRAPH COMPANY. — The annual general meeting of this company will take place on the 16th prox.

POSTAL APPOINTMENT.—Mr. W. H. Callway, telegraph superintendent at Newport, Monmouth, has been appointed postmaster of Swindon.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 12th inst. amounted to £3,027.

THE HAMMOND COMPANY.—From the report in another column it will be seen that the shareholders have resolved upon winding up this company.

THE GREAT NORTHERN TELEGRAPH COMPANY.—A half-yearly interim dividend, at the rate of 5 per cent. per annum, is notified on the shares of this company.

THE DYNAMICABLES.—Instead of their usual meeting this month the Dynamicables have arranged for a visit to-day to Messrs. R. E. Crompton's works at Chelmsford.

LONG DISTANCE TELEPHONY.—A long distance system of telephony by the existent telegraph wires was opened for service on the 1st inst. between Bruxelles and Liège.

APPOINTMENT.—M. Felix Neumann has been appointed Director of the Administration of Posts and Telegraphs of the Grand Duchy of Luxembourg, in place of M. Charles Rischard.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 12th inst., were £2,418, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE SOCIETY OF TELEGRAPH-ENGINEERS.—Invitations have been issued by the president of the above society to visit, by permission of the chairman and directors of the Great Western Railway Company, their engineering works at Swindon on Tuesday, the 30th inst.

THE MILLER PRIZE.—We have great pleasure in announcing that the "Miller Prize" of £20 has been awarded by the Council of the Institution of Civil Engineers to Mr. F. Geere Howard for his very able paper on "Secondary Batteries," read on 16th January at a students' meeting.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th inst. are £2,984, as compared with £3,066 in the corresponding period of 1884. The February receipts, estimated at £4,722, realised £4,854.

A NEW LIGHTNING GUARD.—The general manager of the Pueblo Telephone Company of Mexico has invented a lightning guard for the use of telephone and telegraph companies, which is said to have proved by actual test to be of great importance. Patents have been applied for in Mexico and the United States.

LIGHTING OF DOCK HOUSE.—Messrs. R. E. Crompton and Co. have received instructions from the East and West India Dock Company to light up their London premises, known as "Dock House," Billiter-street. The installation will include a 3½ h.-p. "Otto" gas engine, a Crompton dynamo, and a number of Dr. Frankland's accumulators.

LUXURIOUS VOLUNTEERS.—During the volunteer review at Dunedin, New Zealand, the camp was lit in the evening by the electric light, which was lent by the Harbour Board, and the evening was given up to amusement. The various bands in camp played during the evening, and dancing, kiss in the ring, and other games were kept up with spirit for a couple of hours.

THE TELEGRAPH IN FRANCE.—By order of the Minister of Posts and Telegraphs, the creation of municipal telegraph offices has been authorised in the following communes:—Quintenas (Ardéche), Brusque, Fayet (Aveyron); Chélan (Gers), Saint-Aubin (Gironde), Meylan (Isère), Chaumont-sous-Tharenne (Loir-et-Cher), Molitg (Pyrénées-Orientales), Julienas, Julii (Rhône).

THE ANTWERP EXHIBITION.—The Belgian Government having requested Earl Granville to make appointments of British jurors, his lordship has communicated the following names, among others, to Baron Solvyns, the Belgian Minister:—Section IV. Electricity: Captain Abney, R.E., F.R.S.; Mr. W. H. Preece, F.R.S., assistant engineer and electrician to the Post Office.

EARTHQUAKES IN CASHMERE.—A Reuter's telegram, dated Simla, June 13, says:—Shocks of earthquake continue to be felt in Cashmere at the rate of from eight to ten daily, but their violence is abating. Advices, however, dated the 16th inst., state that the shocks have again occurred with increased violence. It is reported that 2,281 persons have perished in the district of Muzurfurabad.

THE ELECTRIC LIGHT IN ITALY.—The installation for the railway station of San Pierdarena is nearly completed. The dynamos will be driven by two turbines; the nine arc lamps are of 6,000 candle-power each, and the total cost is estimated at £4,000. The little town of Aosta has recently been successfully lighted by Cruto incandescent lamps. The current is supplied by a Thury dynamo.

BREAKING TELEGRAPH INSULATORS.—At the Birmingham Police-court three youths have been fined 5s. each and costs for breaking telegraph insulators. The inspector of the local telegraph department said that no fewer than 2,000 insulators had been broken along the telegraph wire by the side of the Birmingham Canal since January last. Each insulator cost 1s., without reckoning the expence of fixing.

SIXPENNY TELEGRAMS.—The prospects of the Sixpenny Telegrams Bill have not been improved by the advent of a Conservative Government; and in any case there is no likelihood of the scheme coming into operation before the autumn. The Press Association states that Lord John Manners is to be the new Postmaster-General; but we have reason to believe that this appointment had not been filled down to the time of our going to press.

THE ELECTRIC LIGHT AND THE EVOLUTIONARY SQUADRON.—The operations in connection with the visit of the Evolutionary Squadron to Bantry Bay are proceeding with remarkable briskness. A double row of spars tightly lashed together has been spread across the mouth of the bay, and an attempt will be made by the gunboats, which are of about 250 tons displacement, to ride or jump these barriers. The experiment will take place in the night time, and will be lighted by the electric light.

ACCUMULATORS AND INDUCTION COILS.—At the Royal College of Science, Dublin, electrical accumulators are employed in connection with inductoria, for which they are obviously well adapted on account of the very even flow of

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current which they give and of their ability of producing very powerful currents, and more particularly on account of the very slight attendance which they necessitate. Frankland accumulators are employed, which were supplied by Messrs. A. R. Sennett and Co.

THE ELECTRIC LIGHT IN VIENNA.—We understand that Mr. R. E. Crompton has been in Vienna for the last fortnight, making arrangements for carrying out a large installation which he has in hand for the Imperial and Continental Gas Association. We believe Mr. Crompton will have not only the electrical work to carry out, but the engines and boilers will also be placed in his hands. This installation will be one of the largest of its kind, and it is thought the forerunner of many more in other important cities.

THE TELEPHONE AND FIRES.—On the occasion of the recent fire at Whiteley's establishment in Westbourne-grove, the electric street call which the Paddington firemen received was immediately transmitted to the superintendent of the district, Mr. Palmer, at the district depôt in Westminster, and was forwarded thence by telephone to Winchester House, Southwark Bridge-road. Thus three of the chief authorities of the brigade were made acquainted with the serious character of the outbreak in a space of time to be measured by seconds.

THE ELECTRIC LIGHT IN LOWESTOFT.—The electric light will shortly make its first appearance in Lowestoft, Messrs. A. R. Sennett and Co. having received instructions to light up the house of Mr. Youngman. The house will be lighted by means of Frankland accumulators, and the motive power will be derived during the daytime from an engine situated in a brewery at some distance from the house. There is a great opening for electricity in the lighting of residences of owners of mills, factories, &c., situated a short distance from them.

THE COMMERCIAL COMPANY'S CABLES.—The work of duplexing these cables on the Muirhead system is almost completed. The main cables were in the first instance duplexed, the Waterville-Havre section has just been completed, and the Canso-Nova Scotia-New York section is in hand. Altogether the total length of cable duplexed is about 6,800 miles. It might be here stated that the Waterville-Bristol section, consisting of a two-cored cable, has been laid. This work has been carried out under the direct supervision of Dr. Muirhead and Mr. John Muirhead.

TELEGRAPH CABLE FOR THE MORAY FIRTH.—Her Majesty's telegraph ship "Monarch" anchored off Burghead on the 3rd inst., and landed Mr. Cunningham, Mr. Lumsden, &c., of the General Post Office, who inspected the locality for a suitable site for landing the shore end of a cable, which is to be laid across the Moray Firth, and which is necessitated by the extension of the telegraph system to the Shetlands and by the introduction of the sixpenny telegrams. The steamer subsequently left for Helmsdale, where the northern end of the cable is to be connected with the existing telegraph system.

ELECTRICITY IN ASYLUMS FOR THE INSANE.—Messrs. Harrison, Cox-Walker and Co., of Darlington, have contracted to supply the Holloway Sanatorium, which was opened by the Prince and Princess of Wales on Monday last, with an electric tell-tale apparatus similar to that supplied by the same firm to the County Asylum of Worcester. The apparatus will record on a sheet, in the head physician's room, every visit made during the night, at thirty different stations, by the warders of the establishment. Electric fire-alarm apparatus and electric bells are being furnished throughout by the same firm.

THE SS. "GREAT NORTHERN."—The repairing ship of the Eastern and South African Telegraph Company, the "Great Northern," has returned home after a stay of nearly five years on the east coast of Africa. During that time she has, under the able direction of Captain Richardson, and Mr. W. H. Cotterell, the chief electrician, done some very excellent work in connection with the company's cables. We are happy to be able to congratulate Captain Richardson and Mr. Cotterell upon the successful termination of their labours. Holiday-making will, in all probability, occupy their attention for some time to come, and we doubt not that the interval will be enjoyed as much as it is deserved.

CONDUIT FOR UNDERGROUND WIRES.—The Washington *Star* gives the following description of the conduit for the Western Union Telegraph Company's wires which are now being put underground in Washington: "The conduit is made of cypress logs, hollowed out like pump logs. They are laid two abreast, making a double conduit. At spaces of about 450ft. boxes are put in, covered with oblong iron covers at the surface, so that any portion of the cable or conduit can be taken up or examined if the necessity arises. The conduit to be laid through the President's grounds will be of the same character. The logs, or pipes, which have a bore about four inches in diameter, are laid about two feet below the surface of the ground or sidewalk."

THE ELECTRIC LIGHT IN PARIS.—It has been decided to light the Eldorado Café, Boulevard de Strasbourg, by electricity. The lighting will be carried out by 25 to 30 Cance arc lamps and from 35 to 70 Edison incandescents. An Olry and Granddemange engine of 40 horse-power, alimented by a Collet inexplosible boiler, will drive the dynamos, which are of the Gramme type, constructed by the firm of Ducommun, of Mulhouse. The work is to be finished and in order by the middle of next month. The management of the café have a very wise regard for the comfort of their clients during the hot summer months.—The Casino de Bougival was lighted last week by 16 Jablochkoff lamps; and 20 lamps of the same system are installed at the Jardin de Paris in the Champs Elysées. These installations have been put down by the Société l'Eclairage Electrique, who have employed the new Bobenrieth chandeliers to carry the lights.

THE VAN RYSSELBERGHE SYSTEM.—Our contemporary, *L'Etoile Belge*, in a recent issue again refers to the disputed adoption of the Van Rysselberghe system of simultaneous telephony and telegraphy by the French Minister of Posts and Telegraphs. According to our contemporary, M. Sarrien has not only confirmed the initiatory arrangements entered into by his eminent predecessor, M. Cochery, but has contracted with the agents of M. Van Rysselberghe for the sole right of working the patents upon the various telegraphic lines of the Republic. The first line to be so appropriated will be that between Paris and Rheims, followed by another from Paris to Rouen, and finally by a network of lines of greater or lesser importance. M. Sarrien is anxious to extend the use of the telephone to international communication. He proposes to connect Paris with Brussels, Antwerp, &c., and rumour, indeed, saith that projects still more ambitious are not undreamt of.

ELECTRIC LIGHT TESTS.—A further note on this subject says:—The electric light life test which has been going on at the Franklin Institute, Philadelphia, has reached its 1,064th hour. The Edison, the Weston, the Stanley, and the Woodhouse and Rawson Companies competed. The Sawyer-Mann and Brush-Swan Companies were invited, but declined to participate in the trial. Extraordinary precautions were taken

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to prevent access to the lamps except by members of the committee. The lamps were lighted on 11th April, and have burned ever since. When these tests were taken the Edison Company, who had entered 21 lamps, had lost 1; the United States Company, who entered 24, had lost 17; the Stanley Company had lost 19 out of 22, and Woodhouse and Rawson, an English firm, had lost 11, or their whole number entered. The Edison Company used the natural fibre bamboo carbon, while the Weston people used the artificial tamidene carbon.

THE SOUTH AUSTRALIAN TELEGRAPHS.—The reduction in the cost of telegrams between Victoria and New South Wales, viz., a shilling for ten words, has been followed by satisfactory results. During the quarter ending March 31 last year the number of messages transmitted to New South Wales from Victoria was 29,851, and under the reduced rates for the corresponding quarter this year, 39,255, or 31½ per cent. increase; the revenue for the former period was £4,234, and for the latter £4,017, or a reduction of 5 per cent. An expense of nearly £7,000 had been incurred in the construction of a new line from Melbourne to Wodonga, and extra operators had cost £800 per year. Some time ago the authorities in Queensland and New Zealand were asked to agree to a proportionate reduction upon brief telegrams between those colonies and Victoria. The Queensland Government had, however, declined, preferring to see the outcome of the arrangements with Victoria and New South Wales.

THE INTENSITY OF SUN RAYS.—M. Morize, of Rio de Janeiro, has invented an ingenious selenium apparatus for measuring the relative intensities of the rays of the sun at different altitudes above the horizon. It consists of a selenium cylinder prepared according to the plan of Professor Graham Bell, 38 discs of copper being insulated from each other by smaller mica discs, and the edges filled in with selenium. It is insulated by glass supports inside a glass envelope, from which the air has been exhausted. The vessel is elevated in a place where surface reflection does not reach it, and the axis is placed parallel to the axis of the earth, so that the rays of the sun fall normally on the selenium cell, and illuminate the same surface. Its position can be altered to keep up this condition from day to day. A constant current traverses the selenium and a galvanometer in circuit with it. From darkness to the most intense radiation of the sun is the range to be observed, and a scale is graduated accordingly.

LIGHTNING RODS FOR HUMAN BEINGS.—Mr. P. B. Delany, of New York, inventor of the synchronous telegraph system, has, says the *Scientific American*, recently patented a lightning rod for the human body. It consists of a large copper wire that passes down the back, with branches extending along the arms to the hands, and along the legs to the exterior of the shoes and to metal soles thereon. The wearer if provided with this rod may, if standing on the ground, handle electric light wires with impunity; and if out in a thunderstorm would stand a good chance of not being hurt if his rod were struck by lightning. Mr. Delany ought to carry a branch of his rod up the back of the neck, and have it connect with a point on the helmet of the policemen, and so give them protection. It has heretofore been proposed to have lightning rod umbrellas, that is to say, an umbrella provided with a flexible wire that extends from the tip or ferrule over the outside of the umbrella, the wire reaching to and allowed to trail on the ground.

TELEPHONIC CHARGES IN LIVERPOOL.—A correspondent of the Liverpool *Daily Post* writes as follows:—"I am glad to see a movement is being made in the direction of a reduction of the telephonic charges, as it is high time a reduction of at least 50 per cent. was made on the present rates. It is this heavy charge that has debarred hundreds of would-be subscribers from joining and giving to it a fuller and wider scope. We who have been subscribers from the first have a right to complain of this. I cannot conceive on what basis the charges are arrived at by the company. Here, with all subscribers centralised, the charges are £20 per annum; in Oldham, under the same company, with few subscribers spread all over the town, the charge is £12 per annum, with benefit of free use of wire to Manchester. Unless some move is made by the subscribers, the company, no doubt, will be content to rest satisfied with present rates, rendering the same indifferent service. I for one (representing two subscriptions) am not content, and shall withdraw at the year end if an alteration be not made."

ELECTRIC LIGHTING OF TRAINS.—The German Railway Administration are making a series of experiments at Frankfort-on-Main, having for their object the determination of an economical and efficient method of railway carriage lighting. The incandescent lamp, it is needless to say, has been chosen for the purpose. The dynamo was connected up to the wheels of the carriages, and made about 700 revolutions per minute. As soon as the speed of the train exceeded 29 kilometres (17·98 miles) per hour, the dynamo generated sufficient energy to light the incandescent lamps, and charge a battery of accumulators placed in the luggage van. When the speed fell below that limit the dynamo was automatically switched out of circuit, and the current supplied by the battery. The cost of the dynamo and accumulators is said to have been £125, that of the installation for each carriage about £4. The price per lamp hour did not exceed one penny. The experiments were productive of great satisfaction, and we may reasonably hope to see the Administration taking, before very long, active steps to carry out the reform.

THE VOLCANIC ERUPTION IN JAVA.—Letters received from Sourabaya, in Java, contain particulars of the volcanic eruption that has taken place in that country, resulting, it is feared, in great loss of life and destruction of property. Smeroe, which is the principal volcano in East Java, had been showing signs of unusual activity, and early in May a terrible outburst of ashes and lava took place from the crater, which destroyed everything for miles round. Ravines 200 to 300ft. in depth were completely filled up by the streams of lava, and the face of the mountain, which until then was serried and dented by many a chain and glen, is now almost smooth. The coffee estate of Kalieda Bening was destroyed. It is estimated that 500 natives perished, as well as the manager of the estate and his two assistants. In mid-Java the appearance of the Merapi—also a volcano—was giving cause for much anxiety, and a disastrous eruption was dreaded. Volcanic rumblings had been heard from Krakataw Island, off the west coast of Java, accompanied by electric phenomena in the vicinity of the old crater, which nearly two years ago caused so much destruction. It was feared that another eruption was probably not far distant.

SUNDRY INSTALLATIONS.—The Gülcher Electric Light Company have recently extended their installation on the Benares Bridge over the Ganges. This bridge is in course of erection by the Oude and Rohilkund Railway Company, and the work is now carried on at night by means of 16 arc lights and 20 incandescent lamps driven from a No. 4 Gülcher dynamo. The above company have also recently completed the lighting of the grounds of the Crystal Palace, Sydenham, with 14 arc lights of 2,000 candle-power placed on high poles. It is intended to use this installation on *fête* nights, when the

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grounds will be illuminated by the electric lamps and some thousands of oil lamps in coloured globes. The effect on the first night was everything that could be desired. The installation is driven from a No. 5 Gülcher dynamo, the motive power being obtained from a Robey double cylinder portable engine. This company is also extending its business through their New Zealand agents in that colony, and have recently supplied four of their No. 4 dynamos, each machine being capable of running 18 arc lights of 2,000 candle-power each. Messrs. Morewood and Co., Birmingham, have also placed an order for an extension to their already large electric lighting plant. This company has also orders on hand for several large plating dynamos.

ELECTRIC LIGHTING OF A BALL ROOM.—On the 11th inst. Messrs. A. R. Sennett and Co., of Hatton-garden, temporarily installed the electric light at Devonshire-street, Portland-place, on the occasion of a ball given by Mrs. Alexander. The ball room, boudoir, promenade, &c., were very extensive, and on account of the very elaborate way in which they were furnished, the electric light was shown to great advantage. About 150 lamps of various candle-power were employed for the lighting of the ball room, boudoirs, staircase, &c., about 100 of which were placed in the ball room. No fittings of any kind were employed, and a very handsome effect was produced by attaching a number of eight candle-power lamps to the blue brocaded silk curtains and valances of the apartment. In the other parts of the house they were supported on the tree ferns and other suitable positions. The light was very successful and gave great satisfaction. A portable engine, dynamo, and Frankland accumulators were employed, the whole arrangement being carried out by Messrs. Sennett in a little more than two days. We feel that these temporary installations when well carried out cannot fail to be of great service in permanently introducing the electric light, as it is brought under the notice of a great number of persons in one night and frequently leads to permanent installations.

VOLUNTEER TORPEDO SERVICE.—Dr. Fleming writes to the *Pall Mall Gazette* as follows :—"Your notice of the steps being taken to form a volunteer torpedo service for the protection of coast towns is one which should attract considerable attention. The recent developments of practical electricity and electrotechnology have created a large body of men all over the country who are more or less intimate with the apparatus of electricity and with mechanism, and who would, therefore, form a ready material out of which to construct a corps easy to train in matters relating to the use of mechanism. The applications of electricity in war and naval operations are yearly increasing, and it needs but a serious effort to be made to attract into such volunteer service numbers of those to whom things electrical are matters of daily experience. If you would lend to this object a fraction of that powerful assistance you have given and are giving to the question of national defences in general, it is highly probable that something useful would result, and that a volunteer torpedo service might arise composed of men instructed in the application of electricity to naval and military purposes, and who would understand not only torpedo work, but have ability to handle electric lighting for search lights, as well as field telegraphy and telephony, and whose aid in coast defence could not fail in time to become important."

VITIATED ATMOSPHERE. — A contemporary, avowedly devoted to the interests of gas lighting, says :—"According to one of the best authorities on ventilation 300 cubic feet of air per hour are required for every adult person in ordinary living rooms. Peclet says 250 cubic feet are sufficient. Less than this renders the atmosphere stuffy and unhealthy. It is generally admitted that an average adult breathes out from twenty to thirty cubic inches of steam and vitiated air per minute; or, as Dr. Arnott says, a quantity equal in bulk to that of a full sized orange. This vitiated air and steam is respired at a temperature of 90° Fahr., and therefore, by reason of this heat, it immediately ascends to the ceiling, together with the heat and carbonic acid given off from the pores of the skin. This fact, by-the-bye, can be clearly demonstrated by placing a person in the direct rays from a powerful electric lamp, and thus projecting his shadow sharply on a smooth white surface. It will be observed that from every hair of the head and beard, and every fibre of his clothing, a current of heated air in rapid movement is passing upwards towards the ceiling. These currents appear as white lines on the surface of the wall; the cause probably being that the extreme rarefaction of the air by the heat of the body enables the rays of light to pass through them with less refraction than through the denser and more moist surrounding cold air."

THE BIDWELL ELECTRIC RAILWAY.—"The electric railway soon to be constructed along Belmont-avenue, Philadelphia, will," says an American contemporary, "present the novel sight of cars running without any apparent propelling force, free from annoyance of noise, smoke, and dust. The motive power for the cars, which are to be run according to the Bidwell system, will be furnished from a station located somewhere on Belmont-avenue, outside the park. It could, if necessary, be carried *over an indefinite distance.* This system differs from other systems of electric railways in not passing the current through the rails. Guards made of lumber run along the inner side of the rails, and a broad covering projects towards the centre, leaving a narrow slot in the middle of the track. Beneath this cover, and parallel with the rails, properly insulated copper conductors of a semi-tubular shape, are placed. The current is conveyed from the dynamos supplying the power through wires to the terminus of the railway, where connection is made with the copper tubes, and a current is thus sent through the whole length of the road. To propel the car a receiving dynamo or electro-motor is placed in the centre of the car. Connection with the current is made by means of an iron tube passing down through the slot, with branches in either direction in the form of an inverted T. On the end of each branch a small wheel, so placed as to run against the copper conductors, completes the connection, wires being run through the tube from the electro-motor in the car to the wheels. The electricity being passed through the circuit of the track, the operator has but to turn a lever to receive the current in the motor, which immediately revolves, and by an attachment with the wheels of the car propels it in either direction, according as the current is reversed or not. Through the reversal of currents the need of brakes is dispensed with. If necessary, the car can be brought to a sudden stand-still, but the change can be effected as gradually as may be desired. There will, therefore, be no danger of running over persons on the track. The avenue will be lighted with the same current by running wires from the tubes to the lamps, as in ordinary street lighting, while the cars will be illuminated by running a wire from the motor to the incandescent lamps in the interior of the car, *the whole power coming from the single current supplied by the stationary engines* some distance away from the track. If it is desired to heat the cars, another draft is made on the current by passing the electricity through some *poorly conducting substance, as German silver, the electrical energy being thereby dissipated in the form of heat.* These connections are made by means of switches, so that no current need be sent through the branch wires when

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the light or heat is not wanted. An important feature of this railway for the park is the *utter impossibility of trifling with the conductors* and receiving injury from a shock. They are placed beneath the board flooring near the rails, and the only opening is the narrow slot, more than a foot distant, the whole being concealed from view. The road will be about a mile and a quarter long, and ten cars, carrying from fifty to sixty passengers, will be run. To furnish the power for these and to light both the avenue and the cars about 100 horse-power will be required." The italics are our own. Comment is needless. We should, however, like a little explanation as to the precise meaning of trifling with the conductors. We remember an individual attempting to trifle with an omnibus conductor and receiving decided injury from the shock; but perhaps we mistake our contemporary's meaning.

ELECTRICITY AND THE GAS INSTITUTE.—The twenty-second annual general meeting of the members of the Gas Institute was held at the Memorial Hall, Manchester, on the 9th, 10th, and 11th inst. The chair was occupied by the President, Mr. Thomas Newbigging, who, in the course of his address, said :—"It has been the custom of late of certain writers and speakers to say that the recent advent of the electric light has had the effect of infusing new life into the action of the gas authorities of the kingdom. The truth of that assertion I dispute. Undoubtedly the introduction of the electric light in its recent development has led to a demand on the part of the public for more light in the streets and other thoroughfares of our cities and towns. The cry has awakened the authorities of such towns and cities who control the public lighting, from the lethargic state into which they had sunk, and gas engineers, as they were always ready to do, have responded to the demand, and are still prepared to go as far in that direction as the public desire. Whilst on this subject I may be allowed to express the opinion that competition by the electric light in England under existing circumstances is out of the question. Even in countries where gas is sold at 20s. per 1,000 cubic feet, electricity stands but little chance with gas as an illuminant; and how, then, can it possibly compete with gas at, say, 2s. 6d. or 3s. per 1,000? The suggestion may be dismissed as absurd. We are, of course, aware that there are other considerations besides that of mere cost. One of the recommendations of the electric light is that it gives out little or no heat. By one person in a thousand this may be deemed an advantage; but I have yet to learn that the grateful warmth of the gas-flame is objectionable. Stuffy, ill-ventilated rooms are an evil; but it is one for which the architect is to blame, and which the heat of the gas flame can, and will yet be more largely made the means of alleviating. With scarcely an exception, the installations we have had of the electric light in this country for the illumination of extended areas, instead of being testimonials in its favour, have been just so many condemnations of it. They have gone largely to prove how far it is at present from being a dependable and useful light; and they have also revealed how much of ignorance and presumption were concealed beneath the language of *dilettante* scientists, who talked glibly of parcelling out our towns into electrical lighting areas for the benefit of hungry companies. It makes one ashamed to look back to the time when the Parliamentary Committee on the electric light was sitting, and remember the exaggerated and harmful nonsense that was spoken on the subject by men styling themselves leaders in science. I cannot help contrasting their behaviour with that of George Stephenson, in the earlier years of the century, when placed in a similar position in the witness chair of a Commons Committee. An honourable member put the question to him, with a grave face, and in an incredulous tone, 'Now, Mr. Stephenson, do you really think you will be able to run your locomotive engines at a speed of twelve miles an hour?' 'Yes,' replied the great engineer, 'I believe we shall be able eventually to run them at a speed of *twenty* miles an hour.' That was a modest boast, as he had proved the fact before, and he kept well within his actual experience; the others palavered about something of which they were profoundly ignorant. That word 'installation,' by the way, is a high-sounding word, and catches the ear of the unwary; but it is not business, and unfortunately it grates on the ears of a good many sufferers. We usually associate the idea of stability and permanence with the word installation. We speak, for example, of the installation of a bishop; and, when the act or ceremony of installation has been completed, the said bishop begins to fulfil, and continues to fulfil his functions, and perform the duties of his office with continuity and some degree of success, if not always with perfect success—for even bishops are not perfect—yet with such measure of efficiency as poor human nature is capable of. But electric lighting installations hitherto, with but rare exceptions, and these in isolated buildings, have been synonymous with failure. It is not in an assemblage of gas engineers that scientific discovery and progress will fail to meet with due recognition. They view the electric light neither with envious nor unfriendly eyes. It is only the quackery and pretension which are associated with it that calls forth their animadversion; and to these, not a moment too soon, the eyes of the public have been opened. If I might presume to act the part of candid friend of the electricians, I would say—as I said at the very beginning, when the wonders of the dynamo were first displayed—that until you can accumulate and freely distribute a reserve of electrical force, your method of lighting can never prove a success. Engines and belting are not to be depended on, even when they are in duplicate. In short, what electricians should aim at is to make their light as staying as gas light. When they succeed in making the electric light as *staying*, they will have within their grasp the power of making it as *paying* as gas light; but in my humble opinion not before. I am not going to say—what it has become the custom to say—that this spoilt child has 'a great future before it' in the illumination of our towns and their innumerable dwellings. That to me is not at all apparent. If I saw any signs of the fact, assuming it to be a fact, I would be justified in saying, and I would say, that I believe it has a great future before it in that respect. With all the circumstances before us, however—the lengthy record of failure and disaster—it is a mode of talking about things which I do not care to adopt. Doubtless it might be considered the better part of valour to venture on a prophecy of the kind, though it is only a mercenary way of making the best of both lights, as Mr. Facing-both-ways tries to make the 'best of both worlds.' It boils the hard peas of criticism, and saves one's scientific reputation; and then it casts the glamour of the seer about one's speech to profess to look far ahead into the future. I prefer to view the hard facts of the present; to use these as my text, and to put the question, 'Show us your credentials?' Aerial navigation may have a great future before it. There are enthusiasts who have been predicting that for a century; at present it is not very apparent that it has. To say that a thing has 'a great future before it' is often a way of saying that it is a present failure, and that is hardly complimentary. If I were an electrician I would say 'Spare us patronage of that kind.'" Our readers will be able to sift many of these assertions for themselves.

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COMMON MISTAKES IN ELECTRICITY AND MAGNETISM.

BY G. W. VON TUNZELMANN, B.SC.

I.—MAGNETISM.

While looking over the papers in magnetism and electricity worked by students of science classes at the May Examination of the Science and Art Department during the last few years I have been struck by the frequent recurrence of certain mistakes and misapprehensions of a very elementary character. I think it may be of use both to science teachers and to students to call their attention to some of these, which I have specially noted either in these papers or in others which I have had occasion at different times to examine.

Before going into details, I should like to point out that while some of these show clearly that the students have been taught things that are actually untrue, many of them are due to candidates having merely learned to describe certain stock experiments, and to *repeat* explanations of them given by the teacher without having thought out and mastered the principles on which they depend. I will now go on to consider the chief points in detail.

Fundamental Ideas of Magnetism.—A great many blunders arise from pupils being introduced to the conception of "magnetic fluids," or "imaginary magnetic matter," before they have thoroughly mastered the fundamental facts of magnetism. Thus, if they are told that the action of a magnet in the form of a long thin bar may be represented by supposing equal quantities of the two kinds of "magnetic matter" placed at the extremities of the bar, before they fully understand what happens when a magnet is broken into several pieces, they are liable to fall into the common error of explaining other magnetic phenomena by the actual accumulation of something, which they call "magnetic fluid," at the extremities of a magnet, whereas this experiment, if properly understood, would show them that if magnetic phenomena were really due to the existence of such a "fluid," then this "fluid" could not pass from one molecule to another, and therefore they would understand that the accumulation of "magnetic fluid" at the poles of a magnet is not a physical fact, but simply a convenient way of representing the forces exerted by the magnet upon other magnetic bodies.

Distinction between Magnetic Substances and Magnets.—Simple as is the distinction between magnetic substances and magnets, the two are often confused.

The teacher should see that the learner clearly understands that, while any body which is capable of being acted upon by neighbouring bodies in virtue of their magnetism is a magnetic substance, it is a magnet only if in itself it possesses magnetic properties. The mutual actions of these bodies on each other should be fully explained and illustrated, viz. :—

That magnetic substances exert no special action upon each other in virtue of their being magnetic substances;

That the action of magnets on magnetic substances is attractive only;

That the action of magnets on magnets is, under different circumstances, either attractive or repulsive.

Magnetic Induction.—In approaching the subject of magnetic induction, the first thing to impress on the mind of the learner is that whenever a magnetic substance is brought into contact with, or close to, a magnet, it becomes itself a magnet, and remains so until it is removed from the neighbourhood of the magnet, and that in some cases it retains a portion of its magnetism after removal.

Thus, consider the fundamental fact that a magnet attracts a piece of soft iron in its neighbourhood; suppose, for example, that a small iron ball is attracted towards the north end of a magnet. It should first be explained that the effect on the ball is to make it a magnet with its south end next to the north end of the magnet, and its north end more remote. The learner will then be able to understand that, as the distance between the unlike ends is less than that between the like ends, the attraction between the two bodies will be greater than the repulsion, and, therefore, that the observed effect, being the difference between the attraction and repulsion, must be attractive.

As an example of the necessity of the teacher's making sure that this is clearly understood, take the following question :—

A small iron ball is suspended from the north end of a bar magnet; state and explain the effect of placing a similar bar magnet by the side of the first, (1) with similar ends adjacent, (2) with dissimilar ends adjacent.

Answer: The first magnet will magnetise the ball, making the part in contact the south end, and the remote part the north end. The second magnet will, in the first case, act in a similar manner on the ball, which will become a stronger magnet, and, therefore, the attraction will be increased so that there will be no observed effect.

In the second case the second magnet will tend to make the part of the ball in contact with the first a north end, and the remote part a south end. If these two effects were equal the ball would become entirely neutral, and, therefore, being no longer attracted, it would fall. In the case in question the two magnets are of equal strength, but the second is slightly more remote, therefore the ball will remain magnetised in the same sense as at first, but *much* more weakly, and therefore it will fall, unless very small in proportion to the size of the magnets.

The mistake most commonly made in answering a question such as this consists in supposing that the ball falls off when dissimilar ends of the magnets are adjacent, because all the magnetic force of the magnets is employed in attracting each other. As a matter of fact, the magnetising effect of the north end of the first magnet upon the ball will be very slightly increased by the neighbourhood of the south end of the second magnet, as the effect of the second magnet upon the first will be to magnetise it still more strongly, and will therefore increase its magnetising power.

A student who clearly understands the result of such an experiment as this will have no difficulty in satisfactorily explaining the advantage of storing magnets, either with their opposite ends in contact or connected by a "keeper."

Explanation of Magnetic Induction.—I have already pointed out the error which students often fall into in explaining induction by means of "magnetic fluids" from not understanding that the theory is only admissible with the restriction that the fluid is not to pass from one molecule to another.

My own opinion is that with elementary students it is better not to make use of "magnetic fluids" at all, as Weber's "Theory of Magnetic Induction" is very much more satisfactory as an explanation, and is more easily understood. "Magnetic fluids" or "imaginary magnetic matter" may, therefore, very well be left alone, except with advanced students of mathematical electricity, and in their case it is of great use, not as an explanation of what is happening in the magnetised body, but simply as an artifice by means of which magnetic problems may often be put into a convenient form for mathematical treatment.

As Weber's theory is not always to be found in the elementary works commonly used, a short sketch of it may not be out of place here.

Weber's Theory of Magnetic Induction.—Let us suppose that each of the molecules of which a magnetic substance is built up is itself a magnet, but that the axes of these small magnets are turned in every possible direction; the magnetic actions of the molecules will then neutralise one another, so that the body will not act as a magnet, but if either pole of a magnet be brought near to it this pole will attract the unlike poles of the molecules and will repel the like poles, so that the molecules will tend to arrange themselves with their north poles pointing one way and their south poles pointing the other way. The molecules will then all act together, and will form a magnet with the portion nearest to the magnetic pole of unlike polarity to it.

It is clear that this theory will necessarily account for any fact which can be accounted for on the theory of "magnetic fluids," and in addition to its being more comprehensible as an actual explanation it has the advantage of experimental evidence in its support.

For example we know that—

(1) Magnetisation is facilitated by striking the body to be magnetised, or by heating it.

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(2) Bodies, when magnetised, usually undergo a slight change of shape without being altered in size, becoming either longer and thinner or shorter and thicker.

(3) When a piece of iron is suddenly magnetised, or demagnetised, a slight sound is heard.

These facts are very simply explained by Weber's theory, while the theory of magnetic fluids could only account for them by the introduction of additional suppositions.

I will conclude the present paper by suggesting to teachers who are sending up pupils for examination that it would be well to caution them in answering questions, to make quite clear what they mean by the north and south ends of a magnet.

According to the system in ordinary use, the north end of a magnet is the end which would turn towards the north if the magnet were free to move in a horizontal plane. Sir William Thomson calls the end which turns towards the north the south end, because its magnetism is similar to that of the earth's south pole.

If candidates use Sir William Thomson's method, they should be careful to make it clear, as otherwise their answers may be misunderstood.

IMITATION OF THE PHENOMENA OF ELECTRICITY AND MAGNETISM BY MEANS OF LIQUID OR GASEOUS CURRENTS.*

BY M. C. DECHARME.

(Continued from page 67.)

II.—Physical Effects.

1. *Imitation of the Lines of Force obtained with Electric Currents or with Magnets.*—I need only mention the more important of the experiments.

a. To imitate the *lines of force of an electric current in a plane perpendicular to its direction* it is only necessary to blow softly, by a slender, tapering, glass tube, a continuous current of water perpendicularly to a glass plate covered with a thin layer of minium diluted in water; the point of the tube being fixed at a distance of several millimetres from the plate. There is then obtained, around the point of contact of the jet with the plate, a considerable number of concentric circles, formed by particles of the minium, which are very similar to the figures formed by iron filings under the influence of an electric current. Instead of minium very fine iron filings may be employed; the same phenomena are apparent, but for the gain in analogy there is a perceptible loss in fineness of detail.

b. To imitate the *lines of force of an electric current in a plane parallel to its direction, a current of air* should be blown by a tapering tube, held vertically, upon the deposit of minium. The tube is then turned rapidly in a direction parallel to the plate of glass, so that the current may, so to speak, be emitted horizontally. That being done, a series of very short and very compact lines, perpendicular to the direction of the current, forms upon the deposit of minium. The phenomenon is similar to that which occurs when a sheet of paper sprinkled with iron filings is strongly electrified.

c. The lines of force of two parallel electric currents, of the same sign, in a plane perpendicular to their direction, may be imitated by employing two tubes containing water, as in experiment *a*.

d. The imitation of the *lines of force of two parallel electric currents, of opposite sign, in a plane perpendicular to their direction*, is obtained by using two tubes, one of them tapered to emit the liquid, and the other adapted to suck the water and the minium. By the simultaneous action of these tubes, one of which is placed at a distance of several millimetres from the plate, and the other in actual contact with it, a figure is produced which clearly demonstrates the two effects of polarity. The aspiration corresponding to positive electricity, and the blowing to negative electricity.

e. An imitation of similar magnetic phenomena produced by magnets either separate or combined may be effected by similar means; the tubes, however, should not be tapered.

2. *Imitation of the Forms and of the Effects of Electric Discharge.* Tufts, feathers, and other forms taken in the discharge of electricity, rectilinear sparks, ramified, sinuous, &c., are readily imitated by blowing, through a tapered tube, a current of water or of air, in the plane of a plate covered with minium in suspension, and by then displacing the tube until it is parallel to the plate. The star-like spark is exactly imitated by strong suction, through a very small fixed tube, of the minium until it is almost drained. The imitation of the figures of Lichtenberg presents this peculiarity, the effect of the aspiration is that of *positive* electricity, and the breathing or blowing to that of *negative* electricity, results which are not without their importance. If, by the aid of a tapered tube, approached to within about $0^m \cdot 01$ of the plate covered with its layer of aqueous minium, a current of air be directed upon the plate, and the tube be then displaced horizontally, a narrow ridge is produced; one part of the disturbed matter rises to the surface, whilst the other beneath, fixed and motionless, is disposed in fine lines, very concise and compact, perpendicular to the axis of the ridge, and similar to the effect which is produced when an electric discharge traverses a metallic wire and volatilises it between two plates of glass.

The stratifications of the electric light in rarefied gases can also be imitiated by means of the same apparatus and the same methods as in the preceding experiments; a tube more or less large, according to whether the water is to flow or to be blown, is moved horizontally and with great quickness above the plate with its layer of minium, and the current is by this means shown in a straight or a curved line upon the pulverent deposit. For certain effects a current of air may be substituted with advantage for a current of water. The imitation is still more exact when interrupted currents of air are employed, either with a single tube or with twin tubes. The experiment, however, which best illustrates the subject is the following:—A glass syphon, provided with a long arm of india rubber, is arranged vertically, its arm touching the bottom of a vase full of water. As soon as the level of the liquid arrives at a distance of several millimetres from the bottom, a number of infinitesmal bubbles of air penetrate into the tube, and set up a sharp hissing noise. As the flow increases the volume of the bubbles is augmented, and the sound diminishes in height and intensity; at a certain moment the bubbles acquire a speed at which they appear to be fixed and constant, as is the case with the stratifications of the electric light in the Geissler tubes. To complete the illusion, the noise which accompanies the phenomena is analogous to that of the interruptor of the induction coil. *L'éclair en chapelet*, described by M. Planté, can be reproduced by moving the tube of water rapidly above the layer of aqueous minium in such a manner that the drops may be shown in juxtaposition upon the plate. One can also realise, by means analogous to the preceding, various forms which bear a striking resemblance to those of the water-spout, the aurora borealis, and the tails of comets, &c.

III. Chemical Effects.

Imitation of the Electro-chemical Rings of Nobili.—Of all our hydro-dynamical imitations of electrical phenomena this is, perhaps, the most remarkable, and the most conclusive in favour of the similarity of the liquid and the electric currents. The experiment may be arranged in the following manner:—Upon a horizontal plate of glass, covered with a thin and uniform layer of minium in suspension in water (or of any other heavy and insoluble powder such as white lead, vermilion, sulphate of baryta, &c.), is projected a small stream of water, falling from a graduated glass tube, held vertically at a distance of $0^m \cdot 01$ to $0^m \cdot 10$.

Under these conditions a series of concentric rings, more or less in number, unequally spaced, and of different thicknesses, formed by the movement of the pulverent deposit under the impulsive action of the liquid current, are produced upon the plate, around the point of the jet. These rings present, ordinarily, well defined outlines and variations of style which are remarkable for their fineness. Frequently there are to be distinguished very slender rays which traverse the whole concentric system and form symmetrical and varied designs of great delicacy.

The similarity of these rings to those of Nobili will readily be recognised. The clearness, the regularity, the delicacy of the rings, and their beauty as a whole, depend upon the nature

* From the *Journal de Physique*.

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of the powder in suspension, that is to say, upon its density and upon its fineness. The narrower the tube and the more closely it approaches the plate the better defined the rings become. The number and the diameter of the rings vary with the length of the column of liquid and the height of the jet; usually there are four or five, but not unfrequently eight or ten. All the rings of one figure are not of the same clearness; those which are furthest from the centre are the most regular and those in which the outlines are the best drawn. As with the electro-chemical rings the *wave* form of propagation is very apparent.

The only essential difference between the two sorts of rings is that those of Nobili present the gradations of colour of the rainbow. This difference, however, is not altogether absolute, because the primaries are sometimes alternately clear and obscure; and, on the other hand, the hydraulic rings (obtained with perfectly white sulphate of baryta) are not destitute of colour, as may be seen upon examination. In operating with two, three, four, &c., tubes symmetrically disposed, there are produced upon the layer of minium the *equipotential figures* electro-chemically obtained by M. A. Guébhard*, and compared by him to the hydraulic level curves of Lamé.

The imitation of electro-chemical rings which seems the most rational and most akin to those formed by aid of the electric current is perhaps produced by the use of a *continuous current of water*. The following are, briefly, the results I have obtained by this means :—

The current of which I made use flowed from a cylindrical or conical convergent tube (of $0^m{\cdot}002$ to $0^m{\cdot}007$ in diameter, inferior orifice), and fell vertically upon a horizontal plate of black glass, simply *moistened* throughout its extent. The actuating tube was fixed at such a height that at the distance

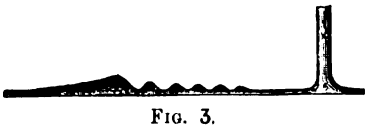

Fig. 3.

where the jet met the plate (a distance variable to $0^m{\cdot}10$ or $0^m{\cdot}15$ in the experiment under discussion) it was continuous, an essential condition. Then the current fell without noise, and produced, around the point of the jet, liquid rings which were perfectly steady. These concentric waves, of which the diameter and the number varied with the experimental conditions, are spaced in exactly the same manner as the electro-chemical rings. Fig. 3 represents in section the formation and the separation of the liquid rings in the case of a single tube.

(To be continued.)

* *Journal de Physique*, 2e Serie, t. 1, p. 205 et 483.

CORRESPONDENCE.

ARMATURE WINDING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Mr. Wilkinson, in your last issue, says that I arrived at an incorrect result when comparing the length of wire on Siemens and Gramme armatures. To avoid the use of "blind mathematics," a subject treated by him in a letter appearing on the same page, I would ask him to take a piece of string, and try the winding on two small models. He will then see that my formulæ are correct. Apparently Mr. Wilkinson has made the mistake of taking n to mean the number of complete turns on the Siemens armature, which would give $2n$ wires on the outside, whilst I take n to mean the number of wires on outer circumference of armature counted all round. To make the comparison fair, this number must be the same in both armatures.—Yours, &c.,

Gisbert Kapp.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Referring to my letter of last week, if we take n as the number of half turns wound on the drum, *i.e.*, the number of wires counted on its periphery, the expressions

$$n(b + 1{\cdot}3d.)$$

for the length of wire coiled on and Mr. Kapp's final equation

$$b = {\cdot}95d$$

are quite correct; the wording, however, employed would lead one to suppose n the number of complete turns on the drum, especially as Nt is previously employed for the number of external wires.

The above relation between the length and diameter of both armature cores is therefore that with which the resistances of both will be equal, when the number of wires on the *outer circumference* of each (not the number of turns) is the same.—Yours, &c.,

H. D. Wilkinson.

School of Electrical Engineering,
Hanover-square, W.

"EDISON'S LATEST INVENTION."

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In last week's number of *The Electrician* you head one of the paragraphs in your "Notes" "Edison's Latest Invention." I have already noticed that Mr. Edison, in conjunction with Mr. Gilliland, has patented in this country "means for signalling or telegraphing between railway trains or between trains and stations by induction," and I presume that your paragraph refers to this patent.

On November 8th, 1883, I read a paper before the Society of Telegraph-Engineers and Electricians, on "Volta-electric Induction," and, at the conclusion of that paper, suggested the way in which induction might be employed for signalling between trains in motion and fixed points, viz: Vol. XII., p. 472, of the *Journal* of the Society of Telegraph-Engineers and Electricians. I much regret that gentlemen connected with the electrical work of the railways in England have not taken more interest in the subject, as I am confident it would form a cheap and efficient adjunct to the present system of railway signalling. Mr. Edison is wrong in supposing that he is the only person who has produced inductive effects 35ft. from the primary source, for, in my experiments, I have far exceeded that distance.

I also wish to call attention to another of your notes—"Hearing the Earth's Magnetic Induction." Similar experiments to those described in that paragraph were experimentally demonstrated during the reading of my paper already referred to, viz., page 469 of the *Journal* named above.

I trouble you to record this, as perhaps when these germs are fully developed it may be convenient to be able to readily fix dates.—Yours, &c.,

Willoughby Smith.

Wharf-road, City-road, June 15, 1885.

BLIND MATHEMATICS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Mr. Wilkinson, in the first of his two numbered instances, attributes the greater heating of the platinum link (in series with a silver link) to its greater resistance. Quite so. And yet the formula $H = \frac{E^2}{R}$, to which I am objecting (and which for the moment he wisely abandons), would teach us that resistance is *unfavourable* to the development of heat.

Am I not correct in supposing your correspondent's real position to be this, that there is greater *local* E.M.F. acting upon the platinum than upon the silver, and as "E" tells in favour of heat at a squared rate, the counter effect due to the sixfold resistance is eclipsed? But if E is to mean not the E.M.F. of the battery, but the local difference of potentials at the extremities of the heated wire, then are we merely in the fire instead of in the frying-pan. For why is there a greater difference of potential in the case of the platinum? Precisely because its resistance is greater. In other words E^2 involves R, which is therefore implicitly above the line as well as below in the fraction $\frac{E^2}{R}$, and the formula is a degree more complex than its parent $H = C^2R$, which it was supposed to simplify.

I am in perfect agreement with Mr. Wilkinson in his facts about the glow-lamps, and admire the prettiness of his illustrations.—Yours, &c.,

E. Aldred Williams.

55, Cornwall-road, W., June 15, 1885.

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ELECTRIC CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If Mons. Adolphe de Bromwere refers to page 529, Vol. XIII., of *The Electrician*, he will there find a brief account of what was not merely a *tour de force* but a practical installation carried out by Messrs. Gaulard and Gibbs, and which included an 80 kilometre circuit between Turin and Lanzo.

Being an exhibit it could not well be permanent, but that it was successful could not be doubted by anyone who, like myself, had an opportunity of observing closely its regular working.

Messrs. Gaulard and Gibbs will doubtless supply your correspondent with any further information he may require.—Yours, &c.,

J. WESTBEECH KEMPSTER.

Chelmsford, June 15, 1885.

THE LATE PROF. FLEEMING JENKIN, LL.D., F.R.S.

The Scottish school of physical science has suffered a heavy loss in the unexpected death, at the comparatively early age of 52 years, of Mr. H. C. Fleeming Jenkin, the distinguished Professor of Engineering in the University of Edinburgh. Since the close of the college session until about a week ago Professor Jenkin was in London actively engaged in developing his recent inventions in electric locomotion, when he returned to Edinburgh to undergo a slight surgical operation. Blood poisoning followed, and after a short illness he died on Friday. The only son of the late Captain Charles Jenkin, R.N., and born at Stowting Court, Kent, in 1833, Mr. Jenkin went to Scotland at an early age, where his first school was Dr. Burnett's, Jedburgh, and his second the Edinburgh Academy. At the age of 13 he went to school at Frankfort, in the following year to Paris, and finally graduated as M.A. of the University of Genoa, where he began his engineering career in 1850. An apprenticeship of three years under Sir W. Fairbairn, of Manchester, followed, and after a varied experience of practical work Mr. Jenkin entered the service of Messrs. Newall, of Birkenhead, in 1857, while they were engaged in the manufacture of the first Atlantic cable. He was entrusted with their chief engineering and electrical work, and in this way had his energies bent in the direction he was afterwards to follow with signal success.

As a pioneer of ocean telegraphy he soon made the acquaintance of Sir William Thomson, and assisted him in the development of the instruments by which the transmission of electric messages over long distances at sea became for the first time practicable. Up to that date electricity had been almost wholly an affair of the text-book and the laboratory, and, though the principles of electrical measurement were known by a select few natural philosophers, no convenient or generally accepted units existed in which electrical magnitudes could be expressed. At the suggestion of Sir W. Thomson, a Committee of the British Association was appointed to determine practical electrical units. Of this committee, whose labours lasted for many years, Mr. Jenkin was one of the most active members, and as secretary wrote many of their reports.

Subsequently Mr. Jenkin entered into partnership with Sir William Thomson as a telegraph engineer, and many of the great submarine cables have been constructed and laid under their supervision. Besides this he joined forces with Sir W. Thomson and with the late Mr. C. F. Varley as patentees of electrical instruments, and as their instruments were the only ones by which signalling through long cables could be economically performed, the patents proved extremely valuable. Recently Prof. Jenkin attacked the problem of electric locomotion with characteristic energy and originality. While other inventors were seeking to devise an electrical locomotive which should take the place of the steam engine on an ordinary railway, he conceived that the line itself should be entirely reconstructed, and the method of working reorganised to suit the conditions of electrical transport; and in this way he invented the system to which he gave the name of Telpherage. During the last two years of his life he was experimenting on this system, and perfecting its details with the utmost ardour, and the first Telpher line was actually in process of construction when he died. Besides his numerous electric patents, he has made inventions in bridge work, hydraulics, mechanical methods of transmitting power, and heat engines. He was juror in Physical Apparatus at the Exhibition of 1862, in Engineering at the Paris Exhibition of 1878, and in Electricity at the Health Exhibition last year. In 1866 he was elected Professor of Engineering in University College, London, but resigned the post in 1868 to take the Chair of Engineering then founded by Sir David Baxter in the University of Edinburgh, and there he has since taught with the greatest success. His class room has already proved the nursery of at least two younger Professors. Neither his duties as a teacher nor his occupations as a consulting engineer, an inventor, and a scientific witness and assessor at the courts were able to engross his activities.

From 1859 onwards he wrote some fifty papers on scientific and social subjects, as well as several text books. Of these last, the principal one—his book on "Electricity and Magnetism" in Messrs. Longman's series of text books of science—which has passed through many editions, and been translated into several foreign languages, is generally accepted as the best existing elementary treatise on electricity. His scientific papers are for the most part to be found in the *Transactions* and *Proceedings* of the Royal Societies of London and Edinburgh, of the former of which he was elected a Fellow at the early age of thirty-two, while of the latter he was made Vice-President in 1879. His papers exhibit much originality. One, published in 1878 (which gained the Keith Prize of the Royal Society of Edinburgh), lays the foundation of an entirely new dynamical theory of machines, which is as much in advance of the merely kinematical analysis of Reulaux as that was in advance of the fragmentary treatment which preceded it.

Apart altogether from his scientific achievements, Professor Jenkin was in many ways a man of remarkable power, and even more remarkable variety. As an accomplished linguist, a *litterateur*, a critic, a metaphysician, a sportsman, no subject seemed out of his ken. Whether the talk was of technical education or the costume of the Greeks, of French plays or the freedom of the will, Mr. Jenkin was sure to contribute a fact, a theory—a paradox, perhaps—but still something fresh and suggestive. Of him even more than of most men it might be said that only his intimate friends really knew him, and his intimates were for the most part specialists in literature or art, or in anything rather than the subjects that formed the main business of his own life. Of his literary work the pages of the *North British Review* for 1868 contain examples, among which an article on the "Atomic Theory of Lucretius" may perhaps be specially named. Other of his writings treat of Darwinism, education, economics, and hygiene. In this last subject he did more and better work than merely that of the pen. In 1877 he organised the Edinburgh Sanitary Protection Association, a co-operative society which secured for its members the benefit of periodic inspection and skilled advice regarding drainage. The idea was novel, and a man of less energy would have found the opposition and prejudice of the public strong. He soon launched the Edinburgh Association on a career of assured prosperity, and then promoted the formation of similar societies in London and other places. A like society was founded in Dundee a little more than a year ago, of which, as of many of the others, Prof. Jenkin was honorary consulting engineer. With other titular distinctions, Prof. Jenkin was an LL.D. of Glasgow University, and an honorary member of the Société Professionelle d'Hygiène of Paris. He leaves a widow and three sons.

We have to thank Prof. A. J. Ewing for the above memoir of the late Prof. Fleeming Jenkin. In addition to what is here stated we would refer readers to the "Electricians' Directory" for 1885 for an epitomised notice of the career of Prof. F. Jenkin. Those who have heard Prof. Jenkin expound the probabilities of the telpherage system will not soon forget the enthusiasm of the man. So far as we are aware the first really public exposition of the scheme was made at the B. A. meeting at Southport, when Prof. Jenkin read a paper in which the telpherage system was explained, and the apparatus shown. More recently at the Society of Arts the system was described, and a model will be found at work at the Inventions Exhibition.

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THE ELECTRICIAN.

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SECONDARY BATTERIES.

The paper which we reprint in this issue, read before the Institution of Civil Engineers, will perhaps draw attention anew to a subject which for a time has been under a cloud. The institution has awarded the "Miller Prize" to this essay, and we do not hesitate to say that professed electricians will agree that the author's work is worthy of such recognition.

The essay bears internal evidence of experience with various forms of the secondary battery, and for this reason the opinion expressed in the concluding sentence has great weight. The author says:—"When once they (secondary batteries) have been so far improved as to be looked upon as trustworthy, a great and lasting impetus will certainly be given to the utilisation of electricity for motive power as well as for lighting purposes." A subject which might well be suggested for the consideration of some of our practical electricians is an exhaustive discussion of the purposes to which secondary batteries might with advantage be put, and the special requirements of each case. One great advantage to constructors is in having a definite object in view, and we now know sufficient of secondary batteries to feel sure they can be modified for specific purposes within certain limits. At the present time secondary batteries have received comparatively but limited patronage. This arises from two causes. The first of these is due to the highly-coloured declarations as to the advantages and state of perfection of the Faure accumulator set forth by promotors of companies. Public opinion failed to grasp the difference between the hopes inspired by a satisfactory laboratory experiment and the matter-of-fact capabilities of every-day work. The idea became quite common that at last an apparatus was devised which would give an efficiency of from 80 to 99·9 per cent. The coolest heads lost their influence, and from the introduction of the Faure accumulator to the present moment purchasers have been seeking not only for what they cannot now obtain but for that which scientific progress is not likely to give them for many years to come. If our forefathers had calculated the theoretic value of one pound or one ton of coal, and refused to entertain the idea of purchase of a steam engine because not one-twentieth, much less one-fiftieth, of that thereotic value could be usefully obtained by such means, the progress of the world would have been somewhat delayed.

The same practical considerations which worked for the introduction of steam are even now working for the introduction of secondary batteries. Many cases arise in which the use of such apparatus is expedient, principally, perhaps, in temporary installations. The use herein is being greatly extended, and is attended with more and more success, till in these cases a breakdown of any kind is almost unknown. Similar success has not hitherto attended the introduction of the more scientific forms of the secondary battery into permanent lighting, though even here breakdowns are becoming more and more rare. The experience already gained in the use and construction of such batteries has led to improvements whereby their life has gradually been increased from hours and days to weeks and months. The second cause to which we would refer is a corollary to the first, in that promises of perfection were made before any experience in manufacture had been gained. Hitherto most attempts to use secondary batteries in large installations have failed because, without rhyme or reason, some of the plates of the battery broke down. The manufacturers were powerless to obtain security against failure. Mr. Howard refers in his essay to the use of secondary batteries as a stand-bye in case of an accident to dynamo or engine, but batteries can only be so used when they may be trusted without fail to work if called upon. No doubt we shall be told that many installations have been made with secondary batteries. We do not dispute the fact, but we dispute the value of the apparatus in these installations, and maintain that it would have been cheaper had reliance in the first instance been placed solely upon the dynamos. The cost has been so great that neither shareholders nor the public will ever get an adequate idea of what it has been, and we are inclined to think that neither directors nor managers have the least inkling of the reality.

It has previously been stated that Mr. Howard's essay is an epitome of the author's experiences, and it undoubtedly contains a large number of practical hints of great value. Exception might, however, be taken to the information as given in the table of storage capacity. The Planté cell, for example, at its period of highest efficiency should give a higher efficiency than the Sellon-Volckmar. In fact the efficiency of the Planté cell varies from a very small to a very high efficiency, and if from a purely theoretical point of view we were asked to name a cell that should give the highest collective efficiency from birth to death, we should couple the simple lead plate and the compressed lead plate as most efficient. The simple lead plate, however, is not generally practical, in that its storage capacity at first is almost *nil*. It requires a long time, and care, in its formation, and the material taken away to obtain porosity serves no useful purpose. We might also point out that a theoretically perfect cell, so far as storage capacity is concerned, is absolutely valueless, unless indeed, Mr. FitzGerald's idea is practically realised that the active machine be in contact with a good conductor which shall remain unacted upon and make good contact under all

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conditions. Mr. Tribe is said to have obtained some very satisfactory results in this direction, but so far we have heard of nothing in this direction except laboratory experiments. Sufficient will have been said for the purpose in view to direct attention to a flagging subject, to show the importance of success, and the many asides that have to be considered by constructors in order to get practical perfection.

SECONDARY BATTERIES.*

BY FRANK GEERE HOWARD, STUD.INST.C.E.

Among the most important discoveries of recent years few have received so much attention, and had such bright prospects, as the accumulators of Planté and their various modifications. All sorts of wild schemes were set afloat for their utilisation, the principal one being to talk about the time when electricity by means of these accumulators could be delivered every morning from house to house like milk. The result of this would have been much the same as if a water company attempted to supply water to its customers by sending round so many gallons every day in carts, or better still a gas company delivering bags full of gas ready for use, one being as impracticable as the other. These ideas were soon dispelled, and then followed disappointment, and of course general condemnation of secondary batteries.

But all this time inventors had been steadily turning their attention in this direction. Many improvements have been introduced, and numbers of difficulties, before considered fatal to them, have been overcome. They are still far from perfect, though it may yet be expected that accumulators or secondary batteries will play the most important part in all extended systems of electric lighting, transmission of power, and the satisfactory solution of the utilisation of wind and water power.

The earliest form of accumulator was a voltameter worked backwards, and was first observed in 1801 by the French chemist, Gautherot. Two years later Ritter, in Germany, carried out a number of experiments in the same direction, and endeavoured to utilise the reaction; he employed for this purpose two plates of gold, separated from each other by flannel kept moistened with acid, and charged by an ordinary Volta's pile. If two pieces of platinum be immersed in dilute sulphuric acid and connected to the two poles of a battery, so that a current be sent through them, the liquid will be decomposed, hydrogen being given off at one plate and oxygen at the other. If then the battery is disconnected and the plates circuited through a galvanometer, it will be seen that they give out a current in the opposite direction to the charging current.

Becquerel first pointed out the real cause of the returned current, upsetting the original theory that the plates absorbed the current during the charging, and gave it up again during the discharge. He showed that the returned current was not due to the storage of electricity, but to the presence of substances having chemical affinities for each other, derived from the decomposition going on during the charge.

If two sheets of ordinary lead be placed in dilute sulphuric acid, and a current be sent through them, a dark brown deposit will form upon the plate connected to the positive pole of the charging battery, due to the formation of peroxide of lead on the surface of that plate, whilst the other will be reduced slightly to spongy lead. Upon disconnecting these plates from the charging source, and circuiting them through a galvanometer, a current will flow from the brown or peroxidised plate to the other reduced plate.

The result is the reduction of the peroxide of lead on the one plate to oxide, and then to sulphate of lead from the presence of the sulphuric acid in the solution; and of the spongy lead to sulphate of lead. Upon recharging, the anode or brown plate, attached to the positive pole of the charging source, will again become peroxidised, and the cathode or other plate reduced to spongy lead. The sulphate of lead will thus disappear from both plates. The plates are thus continually oxidised and deoxidised as they are charged and discharged.

This is a secondary battery in its simplest form, and all accumulators are based upon this principle. Lead has proved by far the best metal for the purpose, because it forms an almost insoluble oxide; a few other metals are nearly insoluble, but lead has the advantage. It is better than silver or manganese, for the reason that its oxide is less soluble than either of them.

The initial electromotive force of a freshly prepared cell when charged is 2·25 volts, but this drops after the first few minutes of the discharge to a little less than 2 volts, which may be taken as the normal electromotive force of a cell made up of peroxide of lead, spongy lead and dilute sulphuric acid. The constancy of the electromotive force of a cell varies considerably with the rate of discharge. If it is run down, or discharged, at a very rapid rate it falls off very quickly; whereas if only a small current be taken out the electromotive force will remain constant for a long time, though the loss on the negative plate or anode from local action will be greater. The strength of the electrolyte or solution varies considerably during the charging or discharging of the cell. When the cell is fully charged the solution is strongest, and when discharged weakest. From this it follows that the internal resistance of a battery is lowest when the electromotive force is at its highest, and the converse. Dr. Frankland has endeavoured to utilise this change in the specific gravity of the solution, to indicate the condition of the cell, and has found that a change of 0·005 in the specific gravity was equal to a storage of 20 ampere hours. This method of determining the state of the cell does not in practice give very good results, on account of the difficulty of getting the solution in the cell to circulate freely, so as to be of the same density throughout.

The first practicable form of accumulator was that of Planté, made in 1860. He took two sheets of lead, and, placing them in dilute sulphuric acid, passed a current through them for some time. Then disconnecting the cell from the charging source, he discharged it, and again charged it, but this time in a reverse direction; so that the lead plate, formerly connected to the positive pole of the charging source, was this time connected to the negative pole. A number of charges and discharges were thus alternately effected until the plates were rendered sufficiently porous to give a satisfactory storage capacity. Planté found that it was necessary to continue this process for some months before a battery was fit for use. Of course when the battery was used the current was sent through it always in the same direction. The reverse charges were only employed to "form" the plates, or render them sufficiently porous to hold a charge. Unfortunately this form of cell, simple as it is, does not store much electrical energy, except when very thin plates are employed, and these soon become brittle and liable to fall to pieces through being entirely converted into peroxide of lead and thereby losing their stability.

According to Géraldy a Planté cell containing 1·445 kilogram of lead is capable of storing 4,983 kilogrammetres of energy, or 11,329 foot-pounds per lb. of lead. De Meritens modified the Planté cell by making the plates out of a number of thin sheets of lead laid one upon the top of the other, and soldering their edges together, thus obtaining plates composed of a number of layers of thin sheet lead.

Kabath again modified this by taking long thin strips of lead which he corrugated by passing them through grooved rollers, and then interleaving them with plain strips, or ribbons of lead, folding them backwards and forwards, until a plate was formed of the required size. The drawback to this form is that the lead used is of necessity very thin, and thus soon breaks down and renders the cell useless. In both these cases the same tedious process of forming as in the Planté cell has to be gone through.

In 1880 Faure devised the plan of pasting red lead, or minium, upon plates of plain lead; this paste was rapidly peroxidised and reduced in one charge, thus overcoming and doing away with the long process of forming the Planté plates. The paste had to be held on the plates by wrapping them in flannel or some such porous material. This increased the internal resistance of the cell, and after a time the flannel began to get

* Paper read at a meeting of Students at the Institute of Civil Engineers.

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rotten and fall off, causing the cell to fail. A much higher storage capacity, however, was obtained, it being 18,000 foot-pounds per lb. of lead and minium. Many improvements have been introduced by Messrs. Sellon and Volckmar, culminating in the form now manufactured by the Electrical Power and Storage Company, which consists of grids of cast-lead with holes from $\frac{1}{4}$ to $\frac{3}{8}$in. square.

The grid used for the anode is made thicker than that for the cathode. These castings are filled with a paste of minium and dilute sulphuric acid. After being dried they are placed in long troughs, filled with dilute sulphuric acid, and a current is sent through them to form them. The amount of current necessary to convert 1lb. of minium to peroxide is 70 ampere-hours, and 140 ampere-hours to reduce it to metallic lead. But as it only needs 110 ampere-hours to reduce 1lb. of litharge, this is generally employed for the cathode plate. After the current has been sent through the plates, they are taken out, washed, and stacked until required for use, when they are mounted in their respective cells, and employed for lighting or other purposes. No felt is put between these plates. They are separated from each other by india rubber bands, pieces of wood, or some similar device.

The storage capacity of this cell is considerably higher than that of the Faure type, being 48,000 foot-pounds per lb. of lead. But since the storage capacity of a theoretically perfect secondary battery is 360,000 foot-pounds per lb. of lead, even the best cell falls far short of this. The figures in Table I. against Sellon-Volckmar are the results obtained from cells specially constructed for driving electric launches, tramcars, &c. Those employed ordinarily for lighting purposes yield about 36,000 foot-pounds per lb. of lead.

Table I.—Storage Capacity of the various Secondary Batteries as regards Ratio of Work to Weight.

Name.	Storage Capacity in foot lbs. per lb. of lead.		Percentage of Efficiency.
Theoretically perfect cell...	360,000	.....	100·00
Sellon-Volckmar	48,000	.....	13·13
Crompton-Fitzgerald	24,000	.....	6·66
Faure	18,000	.....	4·99
Planté	12,000	.....	3·33

It has been proposed by Mr. FitzGerald to substitute carbon for the lead employed for establishing contact with the active material of the cathodes, where oxides of lead are used, and also to protect parts of the anodes by means of some insulating material, so as to arrest the process of peroxidation over the whole of the plates, and thus always to preserve a good contact throughout the anode. A large number of experiments have been carried out in this direction. The best results obtained were from a battery made up of cathodes composed of minium and carbon fragments, held in a punctured lead envelope, and anodes composed of spongy or finely-divided lead, also held in a punctured lead envelope, and protected by a network of insulating material, generally known under the name of Prout's glue. This form had a storage capacity of 24,000 foot-pounds per lb. of lead. Messrs. Beaumont and Biggs' battery is made up of plates of compressed spongy lead. The lead is obtained in this state by precipitation from a solution of acetate, or sugar of lead, in which solution is placed a plate of zinc. Lead, in a state of very fine subdivision, is deposited upon the zinc, from which it is scraped off, put into moulds, and subjected to hydraulic pressure. By this means plates of great porosity are obtained, which should have as high a storage capacity as any known form of battery. Of the numerous batteries in the market, nearly all are modifications of the well-known Planté type, which seems to be the best form for durability, if not for storage capacity; and the "life" of a battery is of far more importance than its storage capacity per lb. weight. The most notable battery of this class, and one coming prominently into notice, is manufactured by the Wolverhampton Electric Light Company, called the Elwell-Parker accumulator. The plates of this battery are made of sheet lead only, but before being formed they are immersed in a strong solution of nitric acid, which attacks the surface of the lead, and honeycombs it to a certain extent. Thus, according to Planté, who first patented this process in 1881, the long process of forming is to a great extent done away with. There seems, however, to be considerable doubt whether this is the case, or if the nitric acid simply dissolves the lead. In all probability the acid attacks the impurities in the lead, and thus prepares the plate in the best possible manner to receive the current. Another battery is the B. T. K., so called from the names of the inventors, Messrs. Beeman, Taylor, and King. This is a modification of the Kabath accumulator, consisting of plates made of alternate corrugated and plain strips of lead wound round and round upon themselves. Batteries of this description are being largely used in the district lighting at Colchester.

An improvement by Dr. Frankland is claimed upon the Sellon-Volckmar type of battery, by hardening the paste of minium, or other oxide of lead used in the plates, by immersing the plates in solutions of sulphuric acid of various densities during different periods. He also claims for the plates the capacity of receiving a higher rate of charge. This hardening mixture may be cast into plates or cylinders of any desired form or size. There are also many other batteries of the Planté type by various inventors. Mr. Joel has patented a plate having a considerable storage capacity. He makes the plates of lead-wool, or, perhaps more properly speaking, lead fibre, mixed with minium, and then pressed upon a cast lead plate which acts both as a conductor and support.

A battery differing in many ways from those already mentioned was that proposed by Sutton. He took two plates, one of lead and the other of copper, and immersed them in a solution of sulphate of copper. The lead plate became peroxidized, and the copper was alternately dissolved and deposited from the solution of sulphate of copper. This battery, though giving good results upon a small scale, failed when used to a large extent. The electromotive force is much lower than that of a cell composed of lead only.

The advantages of accumulators made after the Planté type over those of the Faure type are that they afford a far higher rate of discharge. This property is invaluable for many purposes, as, for instance, where numerous lamps are required to be run for only a short time. But then again accumulators of the Faure type take in a higher rate of charge than the Planté, because they have a greater thickness of working material, and also store a larger amount of electrical energy in a given weight.

The durability, or life, of a secondary battery has never been satisfactorily settled. Manufacturers assert that their accumulators will last for a number of years, but this has not yet been proved. Those of the Sellon-Volckmar type cannot, the author believes, be depended upon to last more than five or six months at the outside when they are worked regularly every day up to their full capacity. But when overcharged continuously, or otherwise improperly used, a few days will often suffice to put them out of order.

The Planté accumulator should last longer than this, but it must be borne in mind that when this battery has arrived at its maximum of efficiency it is on the point of falling to pieces. Where water or steam power is available a rough but serviceable battery may be made by taking sheets of thick lead, cutting them into plates of any required size, and mounting them in tanks filled with dilute sulphuric acid. Of course, during the first few charges the storage capacity will be very small, but this will improve every day; at the same time the cost of forming them is next to nothing. Eventually it will prove to be a most efficient battery.

The first and most important point in setting up a secondary battery is to carefully insulate the cells from each other, and from any moisture. This is best effected by arranging them on wooden shelves raised about 8in. off the floor, and at an equal distance from the walls. The boxes should be left with a space of at least an inch between them, and wherever possible placed in single rows and not upon shelves one on the top of the other, so that free access may be had to each box. In large installations the cells are often of considerable size, weighing from 5 to 6 cwts. each, thus rendering it extremely difficult to move them. For these reasons they should be so arranged that, once

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put up, they can be easily got at for repair without being removed. The importance of keeping the cells perfectly free from moisture can hardly be overrated. If they should be placed upon a damp floor, or in any position where moisture can get at them, there will be a considerable leakage of electricity, the cells will rapidly run down, *i.e.*, become discharged, and will be in all probability condemned as unworkable and useless.

All secondary batteries, when first set up, should be tested for insulation. This may easily be done by connecting one pole of the battery (after it has been charged) to one terminal of an ordinary galvanometer, and the other terminal of the galvanometer to earth. The best way to obtain a good earth is to connect the wire to a water or gas pipe; or if neither of these should be available, to drive a piece of iron into the ground and make a connection in that way. If the needle is deflected it indicates leakage, which should at once be remedied. The leakage will in all probability be found to arise from an escape of the solution from one of the cells, the place where they are standing being damp, or one of the leads "making earth." The poles of the cells should be connected together by stout bars of metal. It is inadvisable to use copper on the positive pole of a cell on account of the rapidity with which it corrodes. Plain lead connections or a mixture of lead and antimony are the most trustworthy. The positive pole of one cell is joined to the negative of the next, and so on all through the series. Then the positive pole of the dynamo is connected to the last positive of the battery, and the negative to the negative. The contacts must be properly made between each cell, as a bad contact will produce a great deal of heat in the cells, thereby introducing resistance into the circuit and reducing materially the rate of charge or discharge. Care should be taken not to charge the battery at too rapid a rate, and if at any time during the charging the cells become warm, the charging should be stopped, and the battery allowed to cool down. The heating of the plates causes them to buckle, often resulting in the short circuiting of the cell, and thus putting it out of use until the defect has been remedied.

During the charging, and also whilst they are at rest, it is advisable to test the cells from time to time. This may be readily done by taking a short length of stout wire, holding one end upon one pole of the cell to be tested, and striking the opposite pole with the other end of the wire. If the cell is in good condition it should give a bright crisp spark. If it gives no spark at all it shows that there is a short circuit in the cell, arising in all likelihood from two of the plates touching each other, or from a small piece of some conducting substance having fallen down between the plates. This should be at once remedied, otherwise the cell should be cut out from the circuit and taken to pieces. It is very important when working batteries to keep all the cells in as even a condition as possible. For if a cell be empty, or is discharged before the others, it will then become recharged in the reverse direction, and thus set up an opposing electromotive force to the rest of the battery; besides there is the risk of spoiling that particular cell. Keeping all the cells in the same condition is best effected by observing them when charging, and cutting out of the circuit all those cells that give off gas freely, and continuing to charge the others until they are all fully charged. If this is done about once in two months, the working efficiency of the battery will be maintained at a very high point. Of course this entails extra labour, but the author contends that secondary batteries do, and always will, require skilled supervision. Care must be taken not to cut out too many cells whilst charging the battery without introducing a corresponding resistance, or the dynamo will be burnt.

The ordinary strength of the electrolyte is 1 part of sul phuric acid to 9 parts of water, or of a specific gravity of 1·2, that of sulphuric acid being 1·84. The water should be as pure as possible. When working a battery, it is necessary to keep all the plates immersed in the electrolyte. If it becomes nccessary to add to the electrolyte, to keep the cell full water only should be used, otherwise the solution will become too strong. When batteries are left out of use for any length of time it is advisable either to remove the solution and wash the plates and boxes with water, or else to leave them fully charged. This latter method is, perhaps, best adopted only when the battery is not to be out of use for very long. It is found that when batteries are left idle and full of solution sulphate of lead will form all over the plates, and have a serious effect upon their future working.

By discharging a cell too rapidly, as much harm can be done to it as by charging it too rapidly.

The best dynamos for charging accumulators are shunt dynamos. Both the series and compound machines are liable to have their poles reversed by the batteries discharging through them, which is likely to arise from the speed of the dynamo decreasing, and thereby having its electromotive force overpowered by that of the battery. This difficulty might be overcome by specially-designed automatic switches. The most economical way is to charge each battery in two series in parallel, though, of course, whilst charging them in this manner, no lights can be run at the same time. The circuit should be so arranged that the dynamo is charging the battery in two series in parallel, or in one series with the lamps in parallel, or dynamo, lamps, and battery all in parallel. In order to charge an accumulator, it is necessary to employ a dynamo giving an electromotive force greater than that of the cells, and greater in proportion to the rate of charge required; but as all excess of electromotive force is lost energy, a slow charge is the most economical where time is of little moment.

The uses to which accumulators may be put are almost endless. They are serviceable for every application of the electric current. Lighting being at present the most in need of them, by employing an accumulator in any installation, the failure of the light should be rendered almost impossible. The chief causes of break-downs are the slipping, or breaking of belts, the heating of the bearings, or some trivial mishap with the engine which may be set right in a few minutes, but which is sufficient to plunge the place so lighted into darkness. Now, by employing accumulators, if the engine has to be stopped, the batteries immediately come into action, and should run the lights long enough for the necessary repairs to be effected. In nine cases out of ten, the failure of the electric light can be traced to some minor breakage or mishap that can be remedied in half an hour or even less; but, of however short duration, a total extinction of the lights must follow when working direct from the dynamo. Again, in almost all factories and workshops where steam-power is used, there is a surplus of from 2 to 4 H.P. This surplus, if employed to drive a small dynamo and to charge batteries all day, would be sufficient to run enough incandescent lamps to light up the whole of the shops in the evening. Accumulators may also be used advantageously in steadying the light when the dynamo is worked by a gas-engine, or any irregular source of power. The only method of satisfactorily solving the problem of the utilisation of water-power is by employing storage batteries, so that the water, instead of running to waste day and night, could be made to store electricity, which in its turn could either be used for motive power or for ordinary lighting purposes, and be drawn off at will. This applies also to the possibility of utilising wind power.

The employment of secondary batteries for driving trains, tramcars, boats, &c., has been a good deal discussed, but up to the present time, although many costly experiments have been undertaken, no practical work has been done.

The first experimental launch worked by accumulators was that fitted up by the Electrical Power Storage Company, and launched at Millwall in September, 1882. She was 25ft. long, 5ft. beam, with accommodation for about ten passengers. She was driven by two Siemens dynamos of the S D_3 type, coupled in parallel. The current was supplied by forty-five 1 horse-power Faure-Sellon-Volckmar cells. The two motors running together absorbed a current of 46 amperes, and developed about 3·75 horse-power. The weight of each motor was 316lb.; that of the countershaft, &c., was 180lb.; and the total weight of the accumulators was 2,520lb., or 56lb. per cell.

The second launch was built by Messrs. Yarrow and Co., of Poplar, and was fitted with all the electrical arrangements by the

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Electrical Power Storage Company for the Vienna Exhibition of 1883. She is 40ft. long, 5ft. beam, and will carry about forty passengers. In this boat the motor and batteries are placed under the floor. The motor used is a Siemens D_2 dynamo, which with eighty Faure-Sellon-Volckmar accumulators (the number carried) will develop 7 horse-power. Its weight is 658lb., and the efficiency when tested was 78 per cent. In this boat no gearing is used between the motor and screw-shaft, the former being coupled directly to the latter. The average speed attained was eight miles per hour. The advantages are that whereas two men are necessary to work a steam launch, the electric launch needs but one man to look after it, as he can steer, stop, or regulate the speed at the same time. An electric launch will also carry more passengers, besides being free from smoke, smell, heat, and noise.

The experiments carried out with tramcars have not yet advanced nearly so far. A trial trip was made on the Gunnersbury and Kew tramway line on the 10th of March, 1883. The experimental car, as in the case of the launch, was fitted up by the Electrical Power Storage Company, and was of the ordinary type used upon the London tramways. It was driven by a Siemens dynamo, designed to work with an electromotive force of 100 volts, and a current of 60 amperes furnished by 50 accumulators placed under the seats of the car. The cells measured 13in. by 11in. by 7in., and weighed 80lb., their total weight being 4,000lb. The storage capacity of each cell was 560 ampere-hours. Apart from this experiment, which did not altogether end successfully, the problem of propelling tramcars has not been solved. The same company exhibited a tricycle at the Vienna Exhibition worked by 21 small accumulators, and a motor designed by Mr. Reckenzaun, of London. This would run for about one hour, and cover about eight miles in that time. The main reason why electricity has not yet been employed for motive power, for boats and tramcars, is, the author thinks, undoubtedly to be traced to the still imperfect and unsatisfactory state of secondary batteries. When once they have been so far improved as to be looked upon as trustworthy, a great and lasting impetus will certainly be given to the utilisation of electricity, for motive power as well as for lighting purposes.

ON THE CALCULATION OF MAINS FOR THE DISTRIBUTION OF ELECTRICITY.*

BY W. H. SNELL, ASSOCIATE.

In any scheme for supplying electric light upon any large scale the determination of the proper sectional area of the conductors is one of the most important problems that we have to solve. It is well understood that, no matter what may be the particular method of distribution which has been adopted, this sectional area must in every part of the system be made to conform as closely as possible to Sir W. Thomson's law of economy; and, therefore, the dimensions of the conductors should be so proportioned that the annual value of the work lost in heating the metal shall equal the annual charge for interest on first cost, maintenance, and depreciation, so far as this is proportionate to their sectional area. These results may possibly require some modification when, at a later stage, we determine (1) the rise of temperature in each section under maximum current, and (2) the distribution of potential throughout the system. But if these considerations demand any serious deviation from the economic standard, it will become a question whether we have selected the most efficient method of distribution.

Determination of Most Probable Value of "C" in the "Equation of Economy."

Now, in the equation of economy we have to make

$$P = P_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where P is the annual value of the heat wasted in the conductor, and P_1 is the annual charge for the cable. P is of the form

$$P = C^2 R K \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where R is the resistance of this section of the cable. K is some constant to be afterwards determined, and C must have a value such that a constant current equal to C would in one year produce the same total heat as does the variable and discontinuous current which is actually transmitted. It is evident that the true value of C will always be an unknown factor, but unless we can get some approximate idea of this value the equation of economy is useless and, indeed, misleading. It is therefore important to consider by what means we may arrive at as close an approximation as the nature of the case will permit. The problem is not in itself one of great simplicity, although it permits of being reduced to a set of quadratic equations.

We see at once that the actual current will vary with the time of the day, with the day of the week, and the period of the year, as well as to a certain extent in an entirely irregular manner; and the difficulty is considerably increased by the fact that the heat wasted in the cable varies, not as the current itself, but as its square. However, it seems probable that in practice we shall usually be able to assign limiting values of C with a fair degree of certainty; and if in any case these limits are too wide to be of much service, we can then, by a sufficient amount of labour, arrive at a still closer approximation. It must be confessed, however, that the method to be proposed for this second approximation is sufficiently clumsy and laborious, and it is very possible that something simpler or more accurate remains to be suggested.

It will be convenient to call the value of C, as above defined, "the mean annual thermal current," or, briefly, "the thermal current." In future we will write it C_θ. Put

$$\frac{C_\theta}{c} = N \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where c is the current required per lamp of normal candle-power; then N is the number of lamps which, if burning continuously all the year round, would cause the same heat waste in the conductor as that actually wasted by the whole of the lamps.

Now, it is also understood that theoretically the size of the conductors should be proportionately diminished as each branch or house wire is taken off, so that the number of amperes per square inch remains constant throughout the system. But it is important to notice that this tapering must not be determined by the actual number of lamps upon the wires, but by the corresponding value of N as just defined. *It is therefore necessary to determine the value of* N *for each section of the cable.* Of course in practice there will be a limit to the frequency with which the dimensions of the conductor can be (economically) adjusted. This limit will probably vary to some extent with the size of the conductors, but for the present we shall assume that the length of each section has been provisionally determined and marked upon the plan.

We may also observe, in passing, that the rule that the number of amperes per square inch of sectional area should be constant throughout the system, is based upon the assumption that the cost of insulation and maintenance bears a constant ratio to the sectional area of the conductor. This is by no means always the case.

Now, the heat generated in any section in any period during which the number of lamps burning is constant is proportionate to the square of the number of lamps supplied through that section, and to the length of the period. If the number of lamps alight varies from time to time, then the total heat generated during the whole period T is proportionate to

$$n_1^2 t_1 + n_2^2 t_2 + \ldots .$$

where t_1, t_2, &c., are the successive periods during which the number of lamps burning is respectively n_1, n_2, &c. Let t_1, t_2, &c., be in hours, and let T be the number of hours in one day, and put

$$n_1^2 t_1 + n_2^2 t_2 + \ldots = N^2 T,$$

so that

$$N = \sqrt{\left(\frac{n_1^2 t_1 + n_2^2 t_2 + \ldots}{T}\right)} \quad . \quad . \quad . \quad (4)$$

Then if for the present we assume that the respective values of n_1, n_2, &c., are constant day by day, N will have the same value as in equation (3), and will represent the number of

*Paper read before the Society of Telegraph-Engineers and Electricians.

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lamps which, if burning continuously, would in twelve months generate the same waste heat as is actually generated.

Now, during the same period, if, as before, n_1, n_2, ... lamps burn for t_1, t_2, . . . hours respectively, the total number of lamp-hours per day is equal to

$$n_1 t_1 + n_2 t_2 + \ldots$$

Put this equal to M T, where M is the number of lamps which, if burning continuously, would give the same total number of lamp-hours per day.

Then we have

$$M = \frac{n_1 t_1 + n_2 t_2 + \ldots}{T} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

And if we also put $c\,M = C_t$, we may call C_t "the mean annual lighting current."

Comparing C_t with C_θ, or, more conveniently, M with N, we can easily see that when $n_1 = n_2 = \ldots$, and also $(t_1 + t_2 + \ldots) = T$, we shall have N = M. This is the case when the actual current is constant and continuous throughout the day; and inasmuch as the sum of the values of t can never be greater than T, it can be shown that N cannot be less than M. Therefore we have for the *minimum possible value* of N,

$$\text{(absolute min.)} \quad N = M \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

But, as we have just seen, this can only be a real value when the values of n_1, n_2, ... are constant and equal to each other, and the period of burning continuous.

As a matter of fact we know that the M T lamp hours are practically performed *within* some period of (say) t hours per day. Let the average number of lamps alight at any one time during these t hours be n, then we shall have

$$n = \frac{M\,T}{t} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Thus the *practical minimum value* of N is given by the equation

$$N = \sqrt{\frac{n^2 t}{T}}, \text{ that is, from (7)}$$

$$\text{(practical min.)} \quad N = M\sqrt{\frac{T}{t}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Next, to obtain the maximum value of N, let the total number of lamps upon the section be μ, and let τ be the average number of hours each lamp is in use per day, so that we have

$$M\,T = n\,t = \mu\,\tau \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Then it is obvious that N will be at a maximum when μ lamps burn τ hours; that is, when

$$N = \mu\sqrt{\frac{\tau}{T}}, \text{ that is, from (9)}$$

$$\text{(max.)} \quad N = \sqrt{M\,\mu} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Thus we have seen that N lies between the limits

$$N\,(\text{min.}) = M\sqrt{\frac{T}{t}} \text{ and } N\,(\text{max.}) = \sqrt{M\,\mu}.$$

In (8) t really represents the total number of hours during which current is supplied, so that under Board of Trade regulations we should have $t = T$ very nearly; but practically nearly all the work will be done within a very much shorter mean annual daily period—perhaps not exceeding six or seven hours—and we may with but little error reduce t in proportion. For instance, let m_1 lamps burn t_1 hours, and after this let m_2 lamps burn during t_2 hours per day, and let $m_2\ t_2$ be small compared with $m_1\ t_1$, then we may put

$$t = \frac{m_1 t_1 + m_2 t_2}{m_1} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

If we use this value of t in (8), the small error thus introduced is in excess.

In illustration of these formulæ let us suppose that on a certain cable supplying 200 lamps a run of 1,000 lamp-hours has been made within a period of 24 hours. Then $M = \frac{1,000}{24} = 42$; that is, the light supplied will have been equal to that of 42 lamps burning continuously throughout the whole time; and the heat wasted in the cable will have been equal to that wasted when N lamps burn continuously throughout the whole time. Then we know that N lies between the limits

$$N = M = 42; \text{ and } N = \sqrt{M\mu} = \sqrt{(200 \times 42)} = 91;$$

that is, the minimum value occurs when 42 lamps burn 24 hours, and the maximum when 200 lamps burn five hours ($\tau = 5$); the heat wasted being thus the same as if 91 lamps had burnt during the whole 24 hours. Suppose, however, that we know further that the whole of the work was performed within some period less than eight hours, so that $t = 8$, then the minimum becomes

$$N = M\sqrt{\frac{T}{t}} = 42\sqrt{3} = 73.$$

Therefore N lies between 73 and 91.

We may suppose the actual case to have been as follows:—

200	lamps burnt	4 hours	= 800	lamp-hours.
150	,,	,, 1 hour	= 150	,,
50	,,	,, 1 ,,	= 50	,,
		Total	1,000	,,

$$\therefore N\sqrt{\left\{\frac{(200^2 \times 4) + (150^2) + (50^2)}{24}\right\}} = 88.$$

Thus we see that whenever we can obtain a value for M and for t we can at once assign the value of the thermal current within certain limits. And these limits become narrower as M increases towards the value of μ, and as t diminishes towards the value of τ.

Suppose, however, that these limits are found to be wider than is desirable to work from, we have a means of obtaining a closer approximation. For this purpose we will examine another method by which we may assign a pair of limiting values for N. Let the lamps upon a given cable be divided into two groups, and assume that our information has enabled us to calculate (directly) the values of the thermal current and of the lighting currents for each group. We have thus obtained the values of N_1, N_2, and of M_1, M_2, and we have to find N and M, *i.e.*, the numbers corresponding to each current for the whole of the lamps upon the cable taken together.

It is evident that as regards M we have simply to put

$$M = M_1 + M_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

But the value of N will largely depend upon the question whether the period of running for the two groups is contemporaneous (wholly or in part) or successive. In fact N lies between the limits

$$N\,(\text{min.}) = \sqrt{(N_1^2 + N_2^2)} \text{ and } N\,(\text{max.}) = (N_1 + N_2).$$

In order to show this, in equation (4) for the value of N we will put t_1, t_2, ... each equal to unity. We can clearly do this with but little error by taking the unit sufficiently small, and taking as many successive values of n as are required.

We shall then have the following equations:—

$$N_1 = \sqrt{\left(\frac{n_1^2 + n_2^2 + \ldots}{T}\right)} \quad . \quad . \quad (12a)$$

$$N_2 = \sqrt{\left(\frac{m_1^2 + m_2^2 + \ldots}{T}\right)} \quad . \quad . \quad (12b)$$

$$\text{and } N = \sqrt{\left\{\frac{(n_1 + m_1)^2 + (n_2 + m_2)^2 + \ldots}{T}\right\}} \quad . \quad . \quad (13)$$

From (12a) and (12b) we have

$$N_1^2\,T = (n_1^2 + n_2^2 + \ldots.) \text{ and } N_2^2\,T = (m_1^2 + m_2^2 + \ldots),$$

and from (13)

$$N^2\,T = \{(n_1^2 + n_2^2 + \ldots) + (m_1^2 + m_2^2 + \ldots) + 2\,(n_1\,m_1 + n_2\,m_2 + \ldots)\}$$

$$\therefore N = \sqrt{\left\{N_1^2 + N_2^2 + \frac{2}{T}(n_1\,m_1 + n_2\,m_2 + \ldots)\right\}} \quad . \quad . \quad (14)$$

In this expression for N put $\frac{2}{T}(n_1\,m_1 + n_2\,m_2 + \ldots) = A$.

Now when the two groups run *successively* it is clear that we shall have $A = o$, because in each of the pairs of coefficients one of the factors will vanish. This gives for the *minimum* value of N

$$N = \sqrt{(N_1^2 + N_2^2)} \quad . \quad . \quad . \quad . \quad . \quad (15)$$

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But when the groups are run contemporaneously throughout A will have its maximum value (all the terms having positive values), and the expression upon the right-hand side of (14) becomes a complete square. This gives for the *maximum* value of N

$$N = (N_1 + N_2) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

We now proceed to compare these limiting values of N with those found by the former process, and to select the lower of the two maxima and the higher of the two minima to form our working limits.

The maxima are $(N_1 + N_2)$ (16) and $(\mu_1 + \mu_2)\sqrt{\frac{\tau}{T}}$, or, as it may be more conveniently written, $\sqrt{\{(\mu_1 + \mu_2)\ (M_1 + M_2)\}}$; these last expressions being obvious developments of (10). It is also obvious that, as the latter of these expressions represents the maximum *possible* value of N, the former cannot be greater than this. That it will usually be considerably less may be seen by taking the maximum value of $(N_1 + N_2)$, which will be $(\sqrt{M_1 \mu_1} + \sqrt{M_2 \mu_2})$, and putting this equal to the maximum possible value of N.

Then if

$$\sqrt{M_1 \mu_1} + \sqrt{M_2 \mu_2} = \sqrt{\{(\mu_1 + \mu_2)\ (M_1 + M_2)\}},$$

we must have $N_1 = \mu_1$ and $M_2 = \mu_2$; that is, all the lamps must burn all the day. It follows that the lower of the two maxima is given by $N = (N_1 + N_2)$.

Taking next the two minima, we have obtained for the general expression of the minimum value of N

$$N = M\sqrt{\frac{T}{t}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

and if the corresponding values of t for N_1 and N_2 be t_1 and t_2, we can write for the minimum

$$N = (M_1 + M_2)\sqrt{\frac{T}{t}} \quad . \quad . \quad . \quad . \quad (17)$$

provided, however, that we have also $t_1 = t_2 = t$. For the present we will assume that this is the case. We have for the second minimum

$$N = \sqrt{(N_1^2 + N_2^2)} \quad . \quad . \quad . \quad . \quad . \quad (15)$$

and we shall show that the former value (17) is always greater than the latter (15), except when either M_1 or $M_2 = o$, in which case they are equal.

It will be sufficient to show that the minimum value of $(M_1 + M_2)\sqrt{\frac{T}{t}}$ is greater than the maximum value of $\sqrt{(N_1^2 + N_2^2)}$. Now the latter expression is at a maximum when $N_1 = \sqrt{M_1 \mu_1}$, and also $N_2 = \sqrt{M_2 \mu_2}$. From this we get for the maximum $\sqrt{(N_1^2 + N_2^2)} = \sqrt{(M_1 \mu_1 + M_2 \mu_2)}$, and this last expression is at a maximum when $M_2 = \mu_1$ and $M_2 = \mu_2$; that is finally, under these conditions, maximum value of

$$\sqrt{(N_1^2 + N_2^2)} + \sqrt{(M_1^2 + M_2^2)} \quad . \quad . \quad . \quad . \quad (18)$$

Again, as t cannot be $> T$, the *least* value of $(M_1 + M_2)\sqrt{\frac{T}{t}}$ is obtained when $t = T$. Thus we have mimimum value of

$$(M_1 + M_2)\sqrt{\frac{T}{t}} = (M_1 + M_2) \quad . \quad . \quad . \quad (19)$$

Now we have always $(M_1 + M_2) > \sqrt{(M_1^2 = M_2)}$, unless either M_1 or $M_2 = 0$, in which case the expressions are equal. Thus we have proved that the higher of the two minimum values is that of equation (17). And therefore finally N lies between the limits

$$N\ (\text{min.}) = (M_1 + M_2)\sqrt{\frac{T}{t}} \text{ and } N\ (\text{max.} = (N_1 + N_2).$$

We have assumed hitherto (for the sake of simplicity) that $t_1 = t_2$. If this is not the case it will make no difference in the results just obtained, but we shall have to find the proper value for t in the minimum (17). For this purpose let t_2 be greater than t_1. From (7) we have

$$n = \frac{M_1 T}{t_1}; \text{ similarly put } m = \frac{M_2 T}{t_2}.$$

Then

$$N_1 = \sqrt{\frac{n_1^2 t_1}{T}}, \text{ and } N_2 = \sqrt{\frac{m_2 t_2}{T}};$$

$$\therefore N = \sqrt{\left\{\frac{(n+m)^2 t_1 + m^2 (t_2 - t_1)}{T}\right\}} \quad . \quad (19a)$$

and we have to find a value for t such that N is also equal to

$$\sqrt{\left\{\frac{(n+m)^2 t}{T}\right\}} = (n+m)\sqrt{\frac{t}{T}} = (M_1 + M_2)\sqrt{\frac{T}{t}}.$$

Equating (19a) with the second of these expressions it will be found that (when $t_1 < t_2$)

$$t = t_1 + \frac{m^2}{(n+m)^2}(t_2 - t_1) \quad . \quad . \quad . \quad . \quad . \quad (20)$$

From this it will be seen that if $m = n$

$$t = \frac{3 t_1 + t_2}{4} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

If m is large compared to n, we have $t = t_2$ nearly. If n is large compared to m, we have $t_1 = t$ nearly.

(To be continued.)

PHILADELPHIA ELECTRICAL EXHIBITION, 1884.*

REPORT OF EXAMINERS.—*Sections V. and VIII.—Electric Lamps.*

The original scheme of committee work divided observations of electric lamps among four different sections, known respectively as the sections on "Arc Lamps," "Carbons for Arc Lamps," "Incandescent Lamps," and "Photometric Measurements." As the membership of all these sections was the same, it was soon found that this subdivision entailed unnecessary work and needless discussion, and the four sections were therefore consolidated into a group, designated by the Executive Committee as Group B.† The work of this group covered the whole subject of measurements on electric lamps.

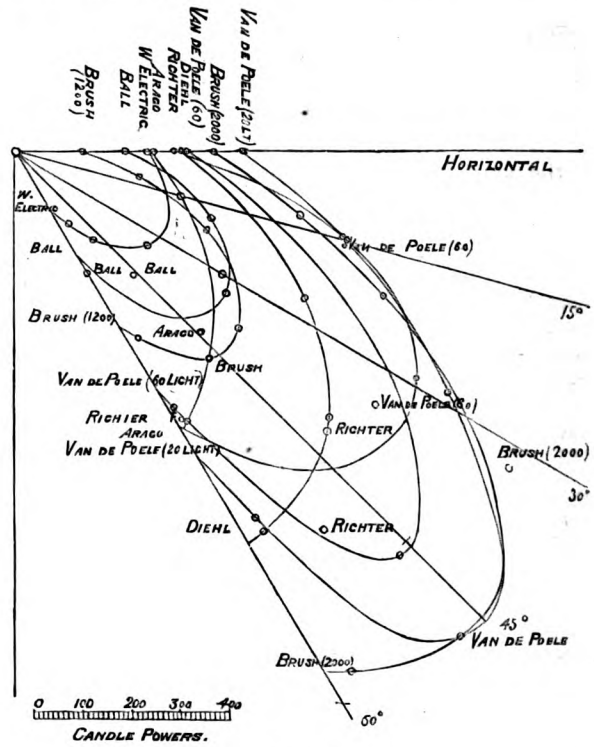

FIG. 1.

It having been long recognised that observations on incandescent lamps by which the *efficiency* only was ascertained were unsatisfactory, the desirability of observations to determine the *life* of lamps was obvious, and endeavours were made to organise such a test. The time required for such work prevented the committee from carrying it out, but the Executive Committee of the Exhibition having offered to arrange such a test the question was considered by the members of Group B, and it was voted that the tests of incandescent lamps should include *duration*, as well as *efficiency* measurements, and that such tests should be carried out under the direction of the Executive Committee of the Franklin Institute for the Exhibition. It was further voted that Group B should co-operate in such tests so far as was possible. A duration test was arranged by the Executive Committee, and invitations to take part therein were extended to the various incandescent lamp companies represented in the Exhibition. The work of Group B was therefore confined to observations of arc lamps.

The examinations of arc lamps consisted mainly in measurements of illuminating power of various angles, from a horizontal plane to sixty degrees below, and in measurements of current and potential at the terminals of the lamp. No attempt was made to examine critically the regu-

* From the *Journal* of the Franklin Institute for June, 1885.

† It was afterwards found advisable to present the report of Section VI. (Carbons) separately from the rest.

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lating mechanism, or to measure the resistances of the regulating coils. The examinations were all conducted at the test house. Each lamp was supplied with current from the machine for which it was especially designed, and was adjusted and put in operation by the exhibitor, who also regulated the strength of the current.

Currents and potentials were measured by the same instruments employed in measurements of machines. The photometric apparatus and methods deserve a brief description. The standard to which all arc lights were referred was an Argand burner and Methven's screen, loaned to the committee by Mr. Wright, of Weston's laboratory, which was accompanied by a certificate from the maker to its exactness as a two-candle standard.

It was tested against two standard candles and found to give the same light and to be much more uniform. This standard was placed at one end of a photometer bar of 450cm. in length, at the other end of which was a 50 candle Swan lamp, serving as a secondary standard. This lamp was fed by a Brush storage battery, furnished and kept charged through the kindness of the representatives of the Brush Company. A second photometer bar making a small angle with the first, extended from this lamp into an adjoining room, where the arc lamp under test was suspended.

To permit of measurements of the light emitted from the arc lamp at various angles with the horizontal, the lamp was suspended from the end of an arm which was free to rotate about a horizontal axis parallel to the photometer bar, but vertically above it at such a height that when the arm was in a horizontal position the lamp could be suspended from its extremity with the arc on a level with the centre of the photometric disc. By this arrangement, when the end of the arm was raised the luminous point described a vertical circle whose axis was a line through the centre of the photometer disc and parallel to the bar. The raidus of this circle was 127 cm. and the distance of its plane from the secondary standard 640 cm. At the centre of this circle was placed a mirror of glass, silvered on the back, at such an angle that the light from the arc lamp falling upon it was reflected along the axis of the circle upon the photometer disc. It will be seen that the distance between the lamp and mirror was thus rendered constant for all elevations of the lamp, that when the mirror was adjusted to reflect the light upon the disc, the angles of incidence and reflection were always 45 deg., and that the distance from the image of the lamp to the secondary standard was always 767 cm. The mirror was carefully tested for absorption and the proper corrections made in the computation of the result.

The general plan of making observations was as follows: The arm from which the lamps were suspended was made horizontal and the height of the lamp adjusted to bring the luminous point on a level with the centre of the mirror and photometer disc. Two observers then adjusted and read the positions of the two discs ten times. The lamp was then raised by raising the end of the arm to which it was suspended and the readings repeated. This was continued until a sufficient number of positions had been taken.

Observations for current strength and for difference of potential between the binding posts of the lamp were made at frequent intervals while the photometric readings were in progress.

To facilitate the comparison of the arc lights with the standard, an apparatus was devised by which one-half or any larger fraction of the light could be cut off at pleasure. This apparatus consisted of a brass disc, about 30cm. in diameter, having 24 sector-shaped openings, all equal to each other and to the metal portions that remained between. Upon this was placed another exactly similar disc, which could be so turned as to close any desired fraction of the openings.

This apparatus was mounted on a spindle placed parallel to the photometer bar, and in such a position that the light from the arc lamp must pass through the openings to reach the photometer disc. When the apparatus was made to revolve at only a moderate rate of speed it was impossible to detect the slightest flicker or inequality in the light in consequence of its use.

In the tests made by your committee, the apparatus was used, when used at all, with the sectors full open, when it was assumed to cut off one half the light as theory would indicate.

Experiment showed that if there is any error in this assumption it is far less than those arising from the unsteadiness of arc lights.

TABLE I.—*Results of Tests on Arc Lamps.*

Lamp.	Altitude.	Candles.	Amperes.	Volts.	Energy in lamp.		Reduced Results.			Remarks.
					Watts.	H.-P.	Altitude.	Candles.	Candles per elec. H.-P.	
Arago	Horizontal.	273	15·41	39·87	614·4	·824	Horizontal	273	332	Fifteen lamps in circuit.
	15 deg. 30′	356	...	...	...	...	15 deg.	350	425	
	30 deg. 15′	505	...	...	...	...	30 ,,	465	565	
	44 deg. 30′	557	...	...	...	...	45 ,,	583	708	
	56 deg. 40′	644	...	...	...	...	60 ,,	645	783	
Ball	Horizontal.	233	6·60	48·83	322·3	·432	Horizontal	233	539	Seventeen lamps in circuit.
	19 deg. 19′	431	...	...	...	...	15 deg.	380	880	
	35 deg. 05′	534	...	...	...	...	30 ,,	520	1,204	
	46 deg. 25′	346	...	...	...	...	45 ,,	485	1,123	
	60 deg. 00′	284	...	...	...	...	60 ,,	182	421	
Brush (1,200) ...	Horizontal.	180	6·62	52·50	347·5	·466	Horizontal	180	386	One lamp in circuit of dead resistance. Lamp very steady, and free from flicker.
	,,	118	...	...	...	...	...	118	253	
	10 deg. 26′	266	...	...	...	...	15 ,,	332	712	
	20 deg. 11′	439	...	...	...	...	30 ,,	537	1,152	
	37 deg. 30′	617	...	...	...	...	45 ,,	613	1,316	
	47 deg.	597	...	...	...	...	60 ,,	355	762	
	56 deg. 35′	422	...	...	...	...	...	...	...	
Brush (2,000) ...	Horizontal.	389	10·32	56·73	585·5	·785	Horizontal	389	496	One lamp in circuit of dead resistance.
	12 deg. 16′	575	...	...	...	...	15 deg.	643	819	
	22 deg. 11′	842	...	...	...	...	30 ,,	1,082	1,379	
	32 deg.	1,253	...	...	...	...	45 ,,	1,373	1,750	
	58 deg. 40′	1,246	...	...	...	...	60 ,,	1,200	1,529	
Diehl	Horizontal.	323	17·67	31·84	562·6	·754	Horizontal	323	428	Four lamps in circuit.
	26 deg. 10′	673	...	...	...	...	15 deg.	496	658	
	38 deg. 30′	809	...	...	...	...	30 ,,	725	961	
	56 deg. 40′	881	...	...	...	...	45 ,,	830	1,101	
	...	...	...	...	...	...	60 ,,	887	1,176	
Richter.....	Horizontal.	313	20·19	30·00	605·7	·812	Horizontal	313	386	Six lamps in circuit. Very unsteady. Carbons fed periodically, current, shown by ammeter in circuit, dropping almost to zero, then up to 25amps., falling slowly to 18, & dropping to zero.
	14 deg. 30′	691	...	...	...	...	15 deg.	700	862	
	29 deg. 15′	956	...	...	...	...	30 ,,	960	1,183	
	41 deg. 25′	813	...	...	...	...	45 ,,	894	1,101	
	50 deg. 30′	986	...	...	...	...	60 ,,	603	743	
	57 deg. 24′	633	...	...	...	...	...	...	...	
Van de Poele ...	Horizontal.	451	16·91	37·88	640·5	·858	Horizontal	451	525	One lamp in circuit of dead resistance. Lamp frequently re-adjusted by exhibitor.
(20-lights.)	15 deg.	701	...	...	...	...	15 deg.	708	825	
	28 deg. 40′	1,020	...	...	...	...	30 ,,	1,060	1,235	
	46 deg. 25′	1,377	...	...	...	...	45 ,,	1,377	1,604	
	56 deg. 24′	848	...	...	...	...	60 ,,	670	780	
Van de Poele ...	Horizontal.	333	13·31	45·77	609·2	·817	Horizontal	333	408	One lamp in circuit of dead resistance. Constant flickering, and frequent fluctuations of considerable magnitude.
(60-lt. machine.)	16 deg.	700	...	...	...	...	15 deg.	535	655	
	34 deg.	890	...	...	...	...	30 ,,	900	1,101	
	46 deg. 25′	1,156	...	...	...	...	45 ,,	1,162	1,423	
	57 deg. 24′	606	...	...	...	...	60 ,,	500	612	
Western Electric	Horizontal.	263	17·89	25·74	460·5	·617	Horizontal	263	426	Twenty-two lamps in circuit.
	30 deg. 30′	355	...	...	...	...	15 deg.	323	523	
	35 deg. 15′	340	...	...	...	...	30 ,,	355	575	
	46 deg. 30′	247	...	...	...	...	45 ,,	266	431	
	52 deg.	183	...	...	...	...	60 ,,	75	121	

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Tables I. and II. embody the results of all the tests.

In Table I, column 1 gives the altitudes of the lamp at which the illuminating power was actually measured.

Column 2 gives the true candle-power for each altitude after applying all corrections. Each result given is a mean of ten observations.

Column 3, the mean of the observations for current.

Column 4, the mean of the observations for difference of potential between binding posts.

Column 5, the electrical energy consumed by the lamp in Watts.

Column 6, the same in horse-powers.

Column 7 gives the candle-powers for each 15 deg. of altitude from the horizontal to 60 deg., as deduced from the curves given in Fig. 1.

Column 9 gives the candles per horse-power for the same elevations.

Under the head of "Remarks" are given such observations as were made, during the progress of the tests, as to the working of the lamps.

Table II. has been compiled to exhibit the results of the observations as to the steadiness of the light. The several columns give the ratios between the arc light and the standard for each of the ten observations for each altitude.

Fig. 1, in p. 104, shows on a system of polar co-ordinates, the relative intensities of the various lamps tested, and the distribution of the light below a horizontal plane. The advantage of placing an arc lamp at a considerable elevation appears very clearly from an inspection of these curves.

TABLE II.—*Variations in Intensity of Lights while under Tests.*

Arago Lamp.					Ball Lamp.					Brush (1,200 Candles).						
Horizontal.	15° 30′	30° 15′	44° 30′	56° 40′	Horizontal.	19° 19′	30° 05′	46° 25′	60° 00′	Horizontal.	Horizontal.	10° 26′	22° 11′	37° 30′	47° 00′	56° 35′
3·35	4·35	6·10	4·50	9·22	2·77	7·12	5·84	5·66	1·49	2·68	1·67	4·53	6·42	9·76	9·76	5·84
4·64	3·93	5·73	4·76	4·97	2·92	6·18	8·37	2·36	1·67	3·11	1·85	4·59	7·03	10·64	11·27	9·35
3·60	5·84	7·93	4·67	9·90	3·31	6·85	9·90	4·03	1·63	3·05	1·81	4·23	7·62	11·11	8·96	7·42
1·87	4·23	6·46	5·84	5·99	3·05	6·42	7·82	6·58	1·42	3·11	1·33	4·64	7·62	10·33	10·18	9·62
2·17	5·06	5·87	6·80	7·82	3·64	6·18	9·76	2·65	4·38	2·83	1·29	4·33	7·42	9·48	9·48	7·72
4·10	3·44	6·68	8·60	9·22	3·02	6·85	8·37	6·34	7·42	3·05	2·53	4·53	7·12	9·48	10·04	6·16
2·01	4·82	8·66	8·20	11·97	3·68	6·94	6·85	9·22	3·68	2·83	2·83	4·33	7·42	9·48	9·09	7·92
5·27	3·23	7·13	5·88	14·86	3·35	5·58	9·76	7·12	4·94	3·08	1·87	4·13	7·03	9·76	9·76	6·18
2·01	...	8·48	9·22	8·90	3·31	7·12	10·18	4·03	8·96	2·89	2·71	4·48	7·32	9·90	8·48	6·42
4·10	...	4·26	15·10	7·67	3·15	6·42	8·04	4·88	7·03	2·77	1·53	4·33	6·34	10·04	9·62	2·53
...	...	...	...	...	...	...	...	...	6·85	...	...	...	...	...	...	...
3·312	4·36	6·73	7·357	9·052*	3·222	6·566	8·489	5·287	4·497*	2·94	1·942	4·41	7·134	9·998	9·664	6·916*
69·2	68·4	63·06	63·54	59·76 †	60·6	55·04	52·76	55·46	53·06 †	54·25	51·06	50·82	51·56	51·74	51·82	51·14 †
1·192	1·192	1·192	1·192	1·172‡	1·92	1·192	1·192	1·192	1·192‡	1·192	1·192	1·192	1·192	1·192	1·192	1·192‡
273	356	505	557	644 §	233	431	534	346	284 §	180	118	266	439	617	597	422 §

Brush (2,000 Candles).					Diehl Lamp.				Richter Lamp.					
Horizontal.	12° 16′	22° 11′	32°	58° 40′	Horizontal.	26° 10′	38° 30′	56·40′	Horizontal.	14° 30′	29° 15′	41° 25′	50° 30′	57° 24′
3·64	5·00	10·33	9·76	14·16	2·19	6·26	4·76	12·70	5·06	10·79	15·59	6·26	7·12	3·02
4·08	4·94	10·33	10·79	16·92	1·77	7·82	7·72	13·51	5·24	13·94	16·11	8·60	10·18	8·60
4·28	5·95	6·34	12·51	14·86	1·01	6·18	9·76	9·90	6·85	12·70	14·63	8·04	8·37	4·94
4·88	4·13	6·94	12·70	13·10	1·55	7·82	13·51	13·51	6·18	12·70	15·59	8·60	7·12	4·33
3·27	6·26	6·50	10·18	11·27	4·28	6·26	9·22	11·96	3·88	13·31	14·39	7·52	10·33	5·68
2·92	4·38	7·32	15·59	14·63	7·12	7·82	11·11	9·09	3·35	9·90	18·72	5·68	10·4	4·76
3·64	6·26	7·42	11·78	5·45	7·42	7·52	7·82	8·84	4·76	11·44	18·09	5·00	7·42	3·39
3·05	4·23	7·52	10·33	9·76	5·68	8·72	12·70	9·35	7·32	11·27	15·59	6·58	7·32	7·62
4·48	8·04	7·22	9·62	10·33	1·46	10·95	12·90	9·76	6·67	14·16	18·40	6·94	8·96	8·60
1·99	4·43	6.50	13·31	6·08	3·98	7·92	4·94	9·35	5·38	11·27	16·11	7·52	9·90	6·00
...	...	...	12·33	...	...	...	...	...	...	...	...	...	...	...
3·623	5·362	7·642	11·72	11·656*	3·646	7·727	9·444	10·797*	5·469	12·148	16·32	7·074	8·676	5·694*
45·05	44·96	46·26	44·84	44·84 †	74·38	73·02	71·80	68·44 †	48·00	47·74	49·14	48·20	47·64	46·64 †
1·192	1·192	1·192	1·192	1·192‡	1·192	1·192	1·192	1·192‡	1·192	1·192	1·192	1·192	1·192	1·192‡
2·	2·	2·	2·	2· ¶	...	...	...	...	...	...	...	2·	2·	2· ¶
389	575	842	1253	1246 §	323	673	809	881 §	313	691	956	813	986	633 §

Van De Poele (20 Light Circuit).					Van De Poele (60 Light Circuit).					Western Electric.				
Horizontal.	15°	28° 40′	46° 25′	56° 24′	Horizontal.	16°	34°	46° 25′	57° 24′	Horizontal.	30° 30′	35° 15′	46° 30′	52°
5·76	·926	6·94	6·04	1·63	3·39	9·1	15·10	15·85	4·08	4·38	6·94	4·64	3·56	2·62
7·03	1·42	3·39	3·98	1·42	4·18	8·86	16·09	8·84	7·22	4·33	2·98	5·12	3·88	2·80
2·83	1·75	3·56	3·68	1·51	3·02	9·90	14·16	11·27	10·79	1·01	3·80	4·28	5·38	3·72
4·03	1·73	4·23	4·94	3·27	3·80	7·23	17·47	7·62	12·51	5·31	5·12	5·38	2·25	3·68
4·28	4·43	4·48	5·60	2·74	3·84	9·90	10·97	13·51	1·75	2·05	5·06	5·18	1·69	1·63
1·55	2·09	4·38	4·45	2·39	6·34	5·58	2·80	15·10	2·11	7·42	5·12	7·72	3·98	2·68
1·87	7·62	3·05	7·62	2·68	2·59	6·78	6·18	17·79	7·52	4·28	8·72	3·08	3·84	2·59
3·08	4·76	4·13	6·76	4·23	3·80	9·22	8·74	18·40	5·84	5·52	4·70	6·00	4·33	3·19
3·60	2·25	3·64	...	6·03	4·13	8·37	6·18	11·78	8·04	2·98	7·32	6·58	6·26	4·18
3·19	2·30	3·68	...	6·10	4·33	7·43	6·76	15·34	11·11	5·24	5·76	6·58	5·68	4·38
3·722	2·928	4·14	5·63	3·200*	3·942	8·237	10·445	13·55	7·097*	4·252	5·552	5·456	4·085	3·147*
101·70	100·45	103·04	102·64	111·20 †	70·94	71·30	71·38	71·54	71·66 †	51·86	53·56	52·22	50·66	48·8 †
1·192	1·192	1·192	1·192	1·192‡	1·192	1·192	1·192	1·192	1·192‡	1·192	1·192	1·192	1·192	1·192‡
...	2·	2·	2·	2· ¶	...	...	...	...	...	...	...	...	...	...
451	701	1020	1377	848 §	333	700	890	1156	606 §	263	355	340	247	183 §

* Indicates Mean, † Standard, ‡ Multiplier, ¶ Disc Multiplier, § Candles.

Note.—The multipliers in Table II. are those by which the intensity of the standard is to be multiplied to give the light of arc lamps, as observed. This product is to be multiplied by the constant 1·192, to allow for loss by reflection, and when the revolving disc was used by 2·. The final product is the intensity of the arc lights in candles.

The variation of the multipliers in any one column is therefore a measurement of the inconstancy of the arc light at that altitude. If the actual variations are desired in candles, each multiplier must be multiplied by the intensity of the standard, by 1·192 and when disc is used by 2·.

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LEGAL.

The Lancashire Maxim-Weston Electric Co. v. The Maxim-Weston Electric Co.

This case was before Vice-Chancellor Sir James Bacon on the 12th inst. in the Chancery Division, when Mr. Marten, Q.C., moved on behalf of the plaintiff company, which is in voluntary liquidation, to have it declared that the defendant company were not entitled to a lien upon the plaintiffs' property for £10,000 in respect of unpaid purchase money due by the defendants to the plaintiffs. The Maxim Company was formed to work an electric light patent in Lancashire, and in December, 1882, they granted in consideration of the payment of £20,000 to them certain licenses in Lancashire, North Wales, and Cheshire to the plaintiffs, the Lancashire Maxim-Weston Electric Light Company. The purchase money was to be paid—£10,000 cash and £10,000 in shares. The plaintiff company had gone into voluntary liquidation, and the £10,000 cash was still unpaid. The defendants thereupon claimed to have a lien for the amount of unpaid purchase money over the plaintiffs' property, and also to be allowed to prove against them. Mr. Hemming, Q.C., appeared for the defendants.

The Vice-Chancellor decided that the defendants had no lien on the plaintiffs' property, but that they should prove in the liquidation for the amount due to them.

COMPANIES' MEETINGS & REPORTS.

The Hammond Electric Light and Power Supply Company (Limited).

An extraordinary general meting of this Company was held on Wednesday, at the Company's office, Appold-street, E.C., for the purpose of considering, and if deemed expedient, passing the subjoined extraordinary resolution, viz.:—"That it has been proved to the satisfaction of this meeting that the Company cannot, by reason of its liabilities, continue its business, and that it is advisable to wind up the same, and accordingly that the Company be wound up voluntarily." Mr. Robert Hammond presided.

The proceedings were private, but the following report has been furnished us by a shareholder. The following circular was taken as read:—

"To the shareholders of the Hammond Electric Light and Power Supply Company (Limited).

"Since the last ordinary general meeting the Board have used every effort to extend the use of the electric light, and early in this year they succeeded in obtaining from the Commissioners of Sewers of the Corporation of the City of London powers in reference to laying electric light mains, &c., in the City, without any of the restrictive clauses of the Electric Lighting Act, 1883. Notwithstanding this valuable concession, the Directors have failed to induce capitalists to subscribe the funds necessary for the starting of the large central station, and the carrying out the necessary work. At Brighton, Eastbourne, and Hastings, however, the Company have succeeded in setting on foot town systems, which will, no doubt, in the course of a few years, prove very remunerative. These installations have necessitated large outlays on plant, and a complete absorption of the Company's funds. But in the direction of isolated installations, the Company have entirely failed to obtain business of a paying nature, and in the carrying out of its operations it has had to keep up a very large and expensive staff, to pay standing charges upon works, royalties, &c., the ultimate result being that the Company finds itself unable, upon its present resources, to continue its business, or to meet its immediate cash liabilities. Under these circumstances, in view of the fact that the Directors see no reasonable probability of a demand arising at an early date for electrical apparatus in sufficient quantities to make the manufacture thereof a remunerative business, they have no alternative in the interests of all concerned, but to set on foot the necessary steps for liquidating the Company's affairs. The Directors also think it desirable to mention that, with their full concurrence, and with the support of the principal creditors, and to secure a favourable realisation of the Company's assets, Mr. Hammond has presented a petition to the Court of Chancery for the winding up of the Company. The Directors confidently believe that by a judicious liquidation of the Company's affairs, and freedom from pressure at the instance of creditors, the liquidator will be able to realise on favourable terms the large stock of Brush and Ferranti dynamos, lamps, and other electrical stock held by the Company, with the probability of an ultimate return to the shareholders, after paying all the creditors of the Company in full."

The CHAIRMAN said the very unpleasant duty devolved upon him of moving the resolution which had been read by the secretary. That resolution said that the Company could not, by reason of its liabilities, continue its business. The bare proof connected with that would take very little time, because it simply resolved itself into comparing the amount in the bank available to pay the debts with the amount the Company owed. According to the statement of affairs which he had before him, they had reduced their banker's balance to a matter of about £30, and there was out in the form of debts a sum of £1,916, which, with calls in arrear, and bills receivable, he found made only £2,100; whereas on the other side they had liabilities amounting to £15,000. A portion of that consisted of bills payable, which were falling due gradually from time to time, and trade creditors of £6,500; £5,000 which they raised on debentures, and £2,000 liabilities on contracts, which, of course, did not press. There was certainly £8,500 which ought to be met almost immediately, while on the other hand, if they collected the whole debts of the Company, they would only have £2,000 to meet that with. It would be an exceedingly unsatisfactory thing to content himself with that bald statement of debtor and creditor as far as the cash was concerned, because no doubt the shareholders would like to know something of the history of the Company since they last met, and something that would show how the assets of the Company had been employed during that time. The endeavour of the Company had been from the very beginning to press forward electric lighting in the best manner, and to do the very best for the Company. If the circumstances of a new industry had been against the Company, and if the legislation which had been set on foot had absolutely prevented the Company from going on, it had not been the fault of that Board. Speaking for himself and colleagues, he was able to say that from the beginning they had given this Company incessant attention. There were many persons who were greatly interested in the electric light, but it had some deadly enemies, who believed that every man connected with it was a thief.

A SHAREHOLDER asked why Sir Charles Young had resigned.

The CHAIRMAN replied that he was sorry to say that during the last year or two the health of Sir Charles Young had not been very good, and he had been strongly advised by his physicians to diminish his responsibility as much as possible. Sir Charles Young said that practically he (Mr. Hammond) was Chairman, and he would like him to preside at the next meeting. Sir Charles was now in the country getting rest, and he had sent a letter showing that his medical advisers urged him to go in the City as little as possible. The Directors had not drawn any fees since the last meeting. This was the closing meeting of the Company, because if they would not be wound up voluntarily it must be done compulsorily. The Directors were endeavouring to save what they could for the benefit of the Company. They were aware that the Company got from the City most valuable concessions for laying mains in the City of London. That was obtained by himself personally through very hard work. He got from the Commissioners of Sewers powers to lay mains in the City without limit of price for electricity, and no purchase clause. Under the Act of 1882 any undertaking was liable to be purchased at the option of the local authorities in 21 years; but he got an Act of Parliament without that limitation. He felt that while they had a chance of carrying that out it was very undesirable to call the shareholders together, and to put before them a balance-sheet, because he was endeavouring by every means in his power to raise money. He first went to the largest shareholders, and consulted them; but they said that they had lost money enough, and did not care to put any more into the concern. He thought until about a fortnight ago that he would be able to get the money. Everyone knew that they had borrowed £5,000 from their bankers, and they felt that they should not hold a meeting such as the one that was now being held until all hope of the City concession was given up. With regard to what the Company had been doing during its life, they must remember that when the Company was started to take over the business which he personally had set on foot, it was shown that the business he had been doing in the various large mills had been a very good one. The Company took over a good business, and the most unfortunate thing that happened to it was obtaining a Stock Exchange quotation. The very success of their Company brought a lot of competitors into the field. Their £2. 10s. shares actually went to £4, and the consequence was that a number of people about the country sprang up who were willing to put up isolated installations for practically nothing. As a private concern he was making £4,000 or £5,000 a year on a capital of £20,000, but as soon as they started as a company 20 or 30 companies were launched who were willing to put up installations merely as an advertisement. The fact was that the business was cut away from under them. It was true that they might have wound up a long time ago, but they felt that the electric lighting industry had an immense future before it, and they also knew that those who had had the light put up had been immensely delighted with it. They believed that electric lighting had as big a future before it as gas. The only thing that they could be blamed for was for waiting on hoping that the fruits would come to them which undoubtedly must come to their successors. At the time that it appeared that they would have a large amount of business they bought from the Brush Company a large amount of Brush plant and machinery. Their money was thus locked up, and Brush machines which cost £320 became only worth £150, and therefore they had had on that account to wipe off very heavy sums of money. They then saw that the great future for electric lighting was house to house installations, and that it was necessary to make a centre from which to supply electricity. They put a certain sum of money into the Eastbourne and Hastings installations in order to make them more successful. At Brighton they began in a shed; but they quickly extended that, and there was no doubt that the installation there, which at present was a loss, could soon be turned into a profit. It only required about £300 to complete their arrangements at Brighton, and then probably 10 or 15 per cent. would be returned on the capital laid out at that place. They had not only demonstrated as no other electric lighting company had done the possibility of house to house lighting, but they went to Parliament, and obtained permission for the lighting of Hampstead. They felt that if once they started house to house installations at Hampstead it would be an immense profit to them. They went to their shareholders and told them of this, and said that they wanted financial help; but their shareholders would not furnish them with a farthing. He did not complain of the shareholders thinking they were in electric lighting too early, and saying that they had lost money enough and would not throw away any more. After all the time he had spent over Hampstead they had to abandon the whole thing. And then in November the bankers of Lombard-street said they wanted to have their

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places lighted by electricity, and it was some compliment to them that they selected this Company as the best fitted to carry out such an undertaking. He sent to the largest shareholders, and said that if they could carry that out they would be able to make all their dead assets live ones, and the plant, which stood at £20,000 to £24,000, might be made to realise that sum instead of being sold under the hammer for what it would fetch. Every shareholder gave him the same answer, that they had lost enough money by electric lighting, that they had been in it too soon, and did not care to put more money into it. Outsiders also said that it was a too risky thing. There was none who would risk £100 in it. He did everything he could to get the money but failed. In the installations they had made they had gone beyond their tether, hoping to realise sufficient to carry out a satisfactory business which would have put them in funds, and then the bankers would have come forward if it had been necessary. In presenting the petition he had done it in the interests of the shareholders, because if the matter had gone into the hands of the creditors they would have been actuated by only one motive, namely, to get 20s. in the pound. He thought it would be advisable that the liquidator should be one who had seen from the beginning the working of the Company. With regard to the £6,000 in dispute, and which was on deposit at the bank, in a recent action their counsel was offered a verdict, but he said that he should prefer to prove his case in order that there might be no appeal, and then the defendant came into court, and as his counsel and solicitor were not present, on payment of the costs of the day he got the Court to adjourn the case, so that that matter was not yet settled. In conclusion the Chairman moved the resolution to wind the Company up voluntarily.

Mr. INCE seconded the motion. He expressed his regret that it was necessary to take the course proposed, and said he felt great sympathy with Mr. Hammond, who had laboured very hard to make the Company a success. He gave them his assurance that Mr. Hammond had done all he could do in the interests of the shareholders. Up to the 11th of this month Mr. Hammond had been striving to get the money for the city lighting, and if he had succeeded they would not have been there to pass a resolution such as the one proposed. It would be seen now that if they had published a balance-sheet at the time the shareholders expected it they would have had no chance of raising £60,000 to £80,000 for the City lighting. He did not believe that there was enough business for any company to succeed in isolated installations, and he did not think that any success would be achieved until the public had confidence, and a large sum was put down, and electric lighting could be proceeded with on a large scale so as to be able to compete with gas.

Mr. REYNOLDS said that the Brush Company was very busy with isolated installations, and they had their machines in all parts of the country. It appeared that there was no hope for this Company unless some shareholders came forward and advanced money; but he would ask whether there was not any chance of amalgamating with the Brush Company? At any rate they might sell their Brush plant back to the Brush Company. He asked how much of that plant they held.

The CHAIRMAN replied about £10,000.

Mr. REYNOLDS said that the Brush Company would give more for it than it would fetch under the hammer.

The CHAIRMAN said that he had approached the Brush Company and had done all he could to get them to amalgamate but ineffectually. The fact was that to carry on the Hammond Company more capital would be required, and the Brush Company would not make a call on their shareholders for that purpose. With regard to selling their plant to the Brush Company, they were unable to do that, as that company had refused to buy it, saying that they were manufacturers of plant and not buyers of it.

Mr. REYNOLDS asked if there was any litigation beyond what the shareholders knew of.

The CHAIRMAN replied that there was not, beyond a few writs for small amounts.

After some further discussion the motion was put to the meeting and carried.

Mr. Theobald was appointed liquidator at a remuneration of 600 guineas; and a committee of three, with power to add to their number, was appointed to confer with him and to see if it would be possible to reconstitute the Company.

The proceedings then terminated.

West Coast of America Telegraph Company.

Report of the Directors to be presented at the eighth ordinary general meeting, to be held at the Cannon-street Hotel, on the 24th inst., at 3 p.m.:—

The accounts for the year ended 31st December last show the gross revenue to be £52,011. 10s. 7d., against the sum of £57,338. 12s. 1d. for the previous year, and leave a nett balance of profit, after paying debenture interest and all other charges, of £14,523. 15s. 6d.—a result which, all things considered, is as satisfactory as could have been looked for, and which has enabled the Directors to commence the regular payment of dividends to shareholders, and to place the Company, by the creation of the reserve fund, in a much stronger and more healthy financial condition. Hitherto dividend payments, after wiping off the enormous arrears in the Company's accounts, have been paid when and so soon as the finances of the Company warranted such payments, but it is now contemplated by the Board to equalise the dividends, so far as practicable, and to make them payable half-yearly. A sum of £12,000 was distributed in dividends in January last year, and a further sum of £6,000 was also distributed in July last year. After the payment of both these amounts, and after placing a sum of £10,000 to reserve, there remains, as will be seen, to the credit of the Company a sum of £3,349. 1s. 3d. Out of this sum, with the object of simplifying the accounts, and fixing each year's dividends on a precise basis, the Board recommend that a final dividend of two shillings per share be declared for last year, with a further interim dividend out of the nett income for the current half year of two shillings per share, making in all a dividend, at this time, of four shillings per share, or a total sum to be distributed of £6,000. The expenditure of the Company for the year shows variations, and in some cases an increase over the expenditure of last year. Wherever an increase is shown, as it is shown in the purchase of cable which has been paid for out of revenue, it need hardly be stated that such increase has been held to be necessary for the maintenance and development of the Company's property and business. The Directors' fees show an increase, and are seemingly large; but this is owing to the extra fees all coming into the present balance-sheet, and in this connection it may as well now be stated that in years past, besides assuming heavy personal responsibilities on behalf of the Company, the Directors have given daily and almost undivided attention to the business of the Company, and have taken for their remuneration only nominal fees of a trifling amount. Regarding the present position and prospects of the Company, the Board have to report that, notwithstanding the fact that in some parts of the coast trade is almost if not entirely suspended, whilst in other parts—if not over the entire coast—trade is, as a whole, in a worse condition than has ever been known, the Company's receipts have not been so far materially affected for the current year, and that the decrease does not amount to more than £1,100 or £1,200, against which it is hoped the next accounts will show a considerable set off in the shape of decreased expenditure. The deplorable internecine struggle on the coast has continued up to this with almost unabated force, but there would seem to be sign that it will soon draw towards its close from sheer exhaustion if from no other cause. The Port of Mollendo, which has been closed and sealed for years, and at which this Company has always kept up a costly but entirely unremunerative station, is to be opened for trade this month, and it is to be hoped that this incident may be regarded as a herald of the restoration of peace and of the revival of trade. The Company's repairing steamer has been kept, and is still kept in the highest state of efficiency, but the Board are pleased to say that so far this year there has been no need to call for her services. The electrical condition and general working of the Company's cables still leave nothing to be desired. The members of the Board retiring by rotation are Mr. Thomas Fielden Campbell and Mr. William Edward MacAndrew, both of whom being eligible offer themselves for re-election. The auditor, Mr J. Weise, of Messrs. Turquand, Youngs, and Co., retires, and is eligible for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JUNE 17.		BUSINESS DONE WEEK ENDING JUNE 17. Highest.		Lowest.
Anglo-American	27½,	28½	28½		27
Do. Preferred	47½,	48½	48⅝		46½
Do. Deferred	7⅛,	8⅛	8⅜		8
Brazilian Submarine	11½,	11⅝	11 5-16		11⅛
Cuba	11¾,	12¼	11¾		11⅛
Do. Preference	18,	19	18		—
Direct Spanish	1½,	2	—		—
Do. Preference	11,	12	—		—
Direct United States Cable	8¾,	9⅛	9⅛		8¾
Eastern Telegraph	11⅝,	11¾	11¾		11⅝
Do. 6 per Cent. Preference	13½,	14	13⅞		13⅝
Do. 5 per Cent. Debentures, 1899	105,	108	107		—
Eastern Extension	12⅜,	12⅝	12⅝		12⅜
German Union	9¼,	9½	9¼		—
Globe Telegraph and Trust	6⅞,	7⅛	7 3-16		7
Do. Preference	12⅞,	13⅛	13⅛		12 15-16
Great Northern	14½,	14⅝	14⅝		14½
Indo-European	80½,	81½	—		—
Reuter's	7½,	8	7⅞		—
Submarine	180,	190	185		—
West India and Panama	⅜,	1	⅜		—
Do. 1st Preference	8,	8½	8⅜		8
Western Brazilian	6,	6¼	—		—
Western Union 7 per Cent. 1st Mortgage	117,	122	—		—
Do. 6 per Cent. Sterling Bonds	100,	103	—		—

TELEPHONES.

Consolid. Telephone and Maintenance	⅛,	¼	⅛		⅛
Oriental	⅛,	¼	—		—
United Telephone	12½,	13	12⅝		12 5-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	1¾	—		—
Do. (fully paid)	3,	3½	3½		—
Hammond Light (£3 15s. paid)	½,	⅝	½		—
Swan	½,	¾	—		—
Maxim-Weston	⅛,	—	—		—

MISCELLANEOUS.

Telegraph Construction	85½,	86½	86½		86
India Rubber, Gutta Percha, and Telegraph Works	24½,	25½	25½		24

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NOTES.

ELECTRICITY AMONGST THE MORMONS.—The Salt Lake City Electric Light Company is paying a fair dividend.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 19th inst. amounted to £3,030.

FIRE ALARM APPARATUS.—Messrs. J. E. Spagnoletti and Crookes have just completed three sets of Spagnoletti's patent fire alarm apparatus for Her Majesty's Post Office.

BOOKS RECEIVED.—A paper on "Electric Lighting," read before the Convention of the National Association of British and Irish Millers, held at Glasgow on the 17th inst., by Mr. Hartnell.

NEW MANUFACTORY.—The creation is announced in Berlin of a large manufactory of electrical apparatus. The necessary funds have been furnished by a group of capitalists in Berlin and Hamburg.

THE CANADIAN TELEGRAPHS.—A telegraph line is about to be built between Moose Jaw and Woodhills, and another is being constructed between Edmonton and Peace Hills by the military authorities.

QUICK WORK.—The announcement of the result of the Derby race, on 3rd June, was transmitted by the Direct United States Cable Company to the Associated Press Office, New York, in exactly three seconds.

PRESENTATION.—The young women employed in the South Australian post and telegraph offices presented Mr. Todd, the Postmaster-General, on the occasion of his departure for Europe, with a travelling bag and fittings.

THE ELECTRIC LIGHT AT GROSVENOR HOUSE.—The Duchess of Westminster gave a dance at Grosvenor House on Thursday night, when the Rubens Room and Picture Gallery were thrown open and illuminated by the electric light for the first time.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 19th inst. were £2,480, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

NEW CABLE.—The Exchange Telegraph Company is informed that it is in contemplation to establish cable communication between Auckland and Fiji. Our most distant colony will thus be connected with Great Britain by wire. The proposal is being warmly supported by the mercantile interests in Auckland.

THE PHYLLOXERA AND ELECTRICITY.—Spanish newspapers announce that the vines in several vineyards near Malaga, which have been abandoned as defunct, have shown evidence of vitality. The destruction of the insects is attributable to the electrical condition of the atmosphere consequent upon the recent earthquakes in Spain.

TOO GOOD TO BE TRUE!—The statement comes from Boston that an inventor there has produced an incandescent lamp which does not require a vacuum. The filament is said to be composed of a platinum wire covered over with a non-combustible material, which will expand and contract with the platinum wire, when heated, without cracking or peeling off.

PRESENTATIONS BY THE SHAH OF PERSIA.—The Shah of Persia has presented to Colonel Bateman-Champain, R.E., and to Lieut.-Colonel Murdoch Smith, R.E., two handsome swords of honour, in token of His Majesty's appreciation of the long services rendered by those officers in connection with the establishment and maintenance of the telegraphs in Persia.

THE ELECTRIC LIGHT FOR WAR SHIPS.—Messrs. R. E. Crompton and Co., of the Arc Electric Light Works, Chelmsford, have completed a projector for an ironclad in the Brazilian Navy, to be used for torpedo warfare. The lamp is of 25,000 candle-power, and with its assistance any object on the sea within a radius of three miles can be detected with great ease.

THE WATERLOO AND CHARING-CROSS ELECTRIC RAILWAY.—On Thursday afternoon the Bill (which has already been sanctioned by the House of Commons) for the abandonment of the authorised electric railway from the loop line of Waterloo Station to the Charing-cross end of Northumberland-avenue, passed unopposed before Lord Redesdale's Committee in the House of Lords.

FORGING A TELEGRAM.—On Wednesday last, at Leeds, Lilian Roberts, a student at Malton College, was remanded on a charge of forging a telegraphic message purporting to be from the Public Prosecutor at Leeds to the Imperial District Court of Justice at Bozen, Austria, authorising the liberation of Max Doring, a photographer of Leeds, who had been apprehended on a charge of felony.

THE BRITISH ASSOCIATION.—The Organising Committee of Section A of the British Association have arranged for the following discussions at the Aberdeen meeting:—(1) "On Kinetic Theories of Gases;" (2) "On Standards of White Light." It would be convenient if those wishing to take part in the discussion would send in their names before the meeting to the Recorder of Section A.

WHO IS HE?—An American contemporary says:—"Reichemberg's system of telegraphing and telephoning on the same wire simultaneously has, it is said, been tried with success between Madrid and Toledo." "Is civilisation a failure," or has our contemporary been misled by the striking similarity of sound between Reichemberg and Van Ryssel-berghe? Anyhow, it looks rather mixed.

LONG-DISTANCE TELEPHONY.—Two German post and telegraph officials, who lately went to Brussels in order to make themselves acquainted with the application of the Van Ryssel-berghe system to the telegraph lines of Belgium, have complimented the Belgian telegraph engineers on the practical arrangements which they made, and Herr Elsasser has given a lecture on the system, published *in extenso* in the *Electrotechnische Zeitschrift*.

COMPRESSED STEEL MAGNETS.—The French Société d'Encouragement has, in consequence of a favourable report by M. Carnot, awarded a platinum medal to M. Clemandot for his steel magnets, compressed to the extent of 15 per cent. of their original volume, and capable of sustaining twenty times their own weight, while retaining their magnetisation to a remarkable degree. The magnets are made of Allevard steel, by M. A. Piat, of Paris.

PROPOSED ELECTRIC LIGHTING AT ST. AUSTELL.—We learn that Mr. J. E. Veale, of North Hill, St. Austell, proposes to put up a central electric light station for the supply of current for 800 or 1,000 lamps throughout the town and immediate neighbourhood if a sufficient number of customers can be secured beforehand. His professional advisers are Mr. Latimer Clark and Mr. Gisbert Kapp, who have independently

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reported on the scheme. Mr. T. M. Coom, of St. Austell, is the resident electrical engineer.

AN ELECTRIC SCALE.—A very important patent has just been assigned, says the *Western Manufacturer*, to an American inventor. It is for an electric scale, which automatically weighs and records consecutively the weights and numbers of objects weighed. This electric device can be attached to any scale, but is especially designed for railways to weigh trains of cars while in motion, and to record weights of same. On a 30 ton scale it will register within 25lb. of actual weight of car and contents, and will record the weights and consecutive numbers of cars weighed while they are passing over the scale at any rate of speed.

THE EASTERN TELEGRAPH COMPANY.—This company announce that, subject to the final audit, the accounts show, after placing £100,000 to reserve fund, a balance available for dividend sufficient to pay at the general meeting on 16th July next, the fixed dividend of 3s. per share less tax, being at the rate of 6 per cent. per annum, on the preference shares, and a final dividend of 2s. 6d. per share with a bonus of 1s. per share, both free of income tax, on the ordinary shares of the company, making with previous payments on account a total dividend of 6 per cent. on those shares for the year ending 31st March last.

TEMPORARY INSTALLATIONS.—At the annual dinner, held at Trinity House, at which the Prince of Wales, the Duke of Edinburgh, the Duke of Cambridge, &c., were present, the rooms were lit by the electric light, supplied by the Electrical Power Storage Company. The light gave so much satisfaction that the company was called upon to repeat it during the course of the following week.—At Mrs. O'Hagan's fancy dress ball a large number of photographs were taken by Mr. Vanderweyde by the electric light, for which one arc lamp, taking 60 amperes, was employed. This was worked for over six hours from E.P.S. cells.

THE TELEGRAPH TO MERV.—A Reuter's telegram dated Simla, June 20, says:—Intelligence has been received here that the Russian telegraph line has been completed to Sarakhs. This is probably the branch from Merv to Sarakhs mentioned in our last issue. The Russian papers say that, at the request of General Komaroff, Governor of the Transcaspian region, the Minister of War has recognised the urgency of immediately establishing a line of telegraph connecting Merv with Askabad. This line would pass by Annow, Babadoorma, Bougatchik, Artchigan, and Sarakhs. Its length will be 500 versts, and the expense about 100,000 roubles.

AN ELECTRIC SUBMARINE BOAT.—Experiments are shortly to be made in Russia, says an American contemporary, with an American submarine boat, which is to be driven by electricity. The boat is to be 28ft. long, and have a speed of 10 knots, and is stated to be capable of travelling for a distance of 15 knots under water. It is to be manned by two men only, the captain and an electrician. The captain's position will be at the stern, where the apparatus for steering the boat is placed. The ventilation will be effected by compressed air. The mines are to be towed, and, in case of the boat being pursued, they can be discharged by electricity so as to blow up the enemy.

ELECTRIC LIGHTING OF BELGIAN RAILWAY STATIONS.—On the 24th inst. the electric lighting of the Courtrai Station, by arc or incandescent lamps, was let by public contract. For the first installation the motive power will be provided, but for the second it must be supplied by the contractor. The State Railway Administration reserves the right of terminating the contract at the end of each year, according to conditions laid down in the specification. Several other stations are also to be electrically lighted before long, as well as parts of the repairing shops at Mons and Gent-Brugge. At the Schaerbeek station the iron columns for carrying the arc lamps are already fixed.

THE NATIONAL TELEPHONE COMPANY.—On the 23rd inst. the Dundee and District Telephonic Company, which has been in existence during the past four or five years, was merged in the National Telephone Company. At a meeting of the local company, held on the same date, it was agreed to sell their business, as at 30th June current, to the National Company for £8,500. It was mentioned that the local company had paid an average dividend of 9 per cent., and that the shareholders would get their capital returned, with a bonus of 40 per cent. The National Company have come under a stipulation that the maximum rate to be charged in Dundee will be the same as in Aberdeen—£10 per annum.

THE TELEPHONE AND FIRES.—Having regard to our remarks in the last issue of *The Electrician* on the subject of the fire at Whiteley's, the Exchange Telegraph Company write to inform us that the alarm given by the telephone enabled the Brigade to arrive at the spot (a distance of about two-thirds of a mile) in five minutes after the signal was sent. The same company's system is employed for the protection of the eastern half of the Inventions Exhibition, and was the means of signalling the first alarm of the recent outbreak at the Indian Museum; and, as Mr. Cunliffe Owen stated in his letter to the *Daily Telegraph* of the 13th inst., the whole of the Exhibition fire staff were at their posts with all their appliances within five minutes of the alarm being given.

NEW REGULATOR.—It is said that a new lamp regulator has been invented by Fein, of Stuttgart. The lower carbon is attached to a plunger, at the bottom of which a float in a liquid is forced upward by hydrostatic pressure. This force is sufficient to form good contact in a small arc lamp of his own design. The support of the lamp contains the float and the carbon; the upper contact is of copper, and is in the form of a wheel, connected to the negative binding post and the frame of the lamp through a short projecting arm and an upright; the carbon connects with the positive through a platinum sleeve, in which it slides. This lamp, with a current of six amperes and six to eight volts, gave, it is alleged, an incandescent light of forty normal candle-power.

THE LUMLEY INCANDESCENT SYSTEM.—In the Lumley incandescent lamp the filament has the shape of a cross. The substance from which this filament is made is a secret, and it is claimed that better results are obtained with it than from those heretofore employed. The lamps range from 10 to 300 candle-power. The dimensions of a Lumley 75 light dynamo machine which was lately in operation at the works in Brooklyn, are as follow:—Length of machine, 2ft. 9in.; height of machine, 1ft. 5in.; width of machine, 1ft. 5in.; length of armature, 9in.; resistance of armature, ·79 ohm; resistance of field, ·78 ohm; E.M.F., 45 volts; current, 75 amperes; number of revolutions per minute, 1,600. The 16-candle lamps have a resistance of 60 ohms, and consequently require three-fourths of an ampere to maintain them.

THE ELECTRIC LIGHT AS AN INSECT DESTROYER.—There is apparently no end to the uses of electricity, and seldom a day passes that some new virtue is not found in this wonderful agent of nature. The most recent discovery is the value of

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the element as a destroyer of insects, and those "horrid thousand-leggers," which the ladies look upon with mortal terror, are exterminated with amazing rapidity by just turning the powerful rays of an electric light upon their ugly little bodies. People have noticed scores of dead centipedes lying on the ground in the vicinity of electric lights, and investigation has disclosed the fact that the rays prove fatal to them without their coming in contact with the flame. Centipedes thrive in dark places, seldom coming out of their coverings during daylight, but it is not known exactly whether it is the powerful ray of the electric light or the small amount of electric current which escapes by induction, which proves fatal to them. There are some insects and fishes which cannot live in the light, and it is thought that the electric rays may be too powerful for the centipedes.—*Electrical World.*

THE TELEPHONE IN CINTRA, PORTUGAL.—The two old Moorish edifices, Pena Castle and Royal Palace, in Cintra, Portugal, were recently telephonically connected by the Edison Gower-Bell Telephone Company of Europe. As all who have visited the favourite summer resort of Cintra are aware, the castle is built on the summit of precipitous rock mountains, ascent to which is impossible except by means of the circuitous pathway. The wire employed was No. 14 B.W.G. steel, jointed to a few yards of No. 8 on either side of the insulator. The first of the latter was fixed high up one of the "Champagne" chimneys of the Royal palace, from thence to the ruined Moorish castle, and from thence to the Pena Castle. Those who have visited Cintra can easily understand the enormous difficulties which would necessarily be encountered in passing the line wire over the thousands of trees which cover the intervening ground, and also on account of the dangerous nature of the rocks for any ascent other than by the beaten circuitous track. To overcome these difficulties a novel innovation in the passing of telephone wire was adopted by Mr. Alan Danvers, the company's engineer. Rockets, with thin cords attached, were fired over the rocks and trees, the line wire being then attached to the cord and pulled after it.

THE CYCLONE AT ADEN.—Mr. Chevallier, the Superintendent of the Eastern Telegraph Company's Station, at Aden, writing on the 7th inst., gives the following account of the severe cyclone which recently passed over that district. He says:—"Last Wednesday was a day that will be long remembered in Aden. It rained hard all Tuesday night, and the sea was rough. At 9:24 a.m. we lost Bombay, and called him for some time on both cables. We tested, and concluded Bombay had earthed for monsoon storm without telling us. The fearful cyclone raging here at the time perhaps gave colour to this, and both cables being down together we never doubted the accuracy of our results. The testing room was dark, and the error was doubtless due to mistaking the ratio of bridge; on further testing we found faults were close to Aden. The cyclone raged furiously nearly all day, the force of the wind was supposed to be 100 miles per hour. Our quarters, being built from the solid rock, were not shifted, but we suffered terribly from broken windows, 56 panes of glass were blown in, and the instrument room presented a desolate appearance, the tables being covered with *débris* of broken windows and the floor flooded. Hardly a kutcha bungalow is left standing in Aden, and the natives inform me that our new possession, "Sheikh Otthman," is completely destroyed."

THE EARTHQUAKES.—Information has been received at the Hague from Java that the state of Krakatoa was causing some anxiety. Towards the end of April subterranean sounds were heard in the neighbourhood day after day, and flames arose from the crater. The rocks which emerged from the sea during the last eruption suddenly disappeared. Official reports have now come in with respect to the recent earthquakes in Cashmere, concerning which the earlier reports were so conflicting. The loss of human life has been ascertained to amount to 3,081. Investigations are being made with a view to a fuller and more scientific report on the phenomenon. A Reuter's telegram from Simla on June 20 says:—"A further despatch from the British Resident in Cashmere states that shocks of earthquake still continue, and that altogether 2,700 persons have been killed in the district of Camraj. The town of Baramula was completely destroyed by a severe shock on the 17th inst. An officer of the Geological Survey Department has been sent to examine the district and report upon the extent of the disaster. Advices from Berne, Switzerland, on June 20, state that several severe shocks of earthquake have occurred in that vicinity. The vibrations were also felt at Geneva. It is stated from Tiflis that a severe earthquake has occurred in the Eastern Caucasus. The town of Sikuch is said to have been completely swallowed up. The loss of property is estimated at several million roubles.

THE DYNAMICABLES AT CHELMSFORD.—On Friday, the 19th, many of the members of the Dynamicables enjoyed a pleasant diversion from their ordinary method of meeting in a visit to Messrs. Crompton and Co.'s works at Chelmsford. In the early part of the day a number of the more active of the younger members of the Dynamicables met at Liverpool-street, and went to Chelmsford to try conclusions at cricket with the Arcadians, a club supported by the pupils of this establishment. Although the Dynamicables were beaten, sufficient good form was shown to prove that, with a little trouble, a very good, if not a very strong, eleven might be made up from among the members, and it was afterwards suggested at the dinner that a cricket club should be formed among the Dynamicables. We trust this suggestion will be carried out. The following are the scores of the respective sides:—For the Arcadians, Albright 48, Williams 11, Bright 4, Dymond 47, Foster 10, Bowling 10, Wilder 3, Sorrenson 1, Stevenson 0, Robinson 1, Scrutton 11, extras 22. Total, 168. For the Dynamicables, S. Rawson 47, Joel 0, Sharp 4, Mountain 6, Defries 28, Crompton 0, Biggs 9, Ferranti 3, Kyle 4, Ram 1, Rawson 0, extras 7. Total, 109. The Dynamicables were entertained at luncheon by their victorious adversaries. Meanwhile other members of the society had gone to Chelmsford in order to inspect the very extensive works of Messrs Crompton and Co. The suggestion of paying such visits is a good one, and great interest was shown by the members of the society. The inspection of the works being finished, the members dined together at the Saracen's Head, and after a very enjoyable day returned to town.

SEPARATION OF ORE BY ELECTRICITY—A PROBLEM.—According to a contemporary, "the invention of a Swedish engineer, Herr Wenstrom, a machine for separating iron ore, is attracting considerable attention in Sweden. It consists of a hollow cylinder rotating horizontally, *with cog wheels at the ends, by which it is set in motion. In the centre of the cylinder is a kind of drum of iron bars, below which an electric battery is placed, which always remains stationary, and is set in motion by a dynamo machine and wire, having the effect of making the iron drum highly magnetic.* As the cylinder rotates iron ores are fed over the same, and which adhere to the cylinder when under the influence of the battery, but fall to the ground as soon as this—on the reverse side—ceases to attract. The machine is so constructed that it separates the ore into three

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heaps, according to their richness. The feeding of the machine has to be done very carefully, and only crushed ore can be separated. The power required is very small, and the revolutions of the cylinder are twelve strokes per minute. Successful experiments have recently been made with the machine at the Koping Engineering Works." We fail to see anything very novel in this process, but the description of its construction as given by our contemporary certainly affords food for thought, and opens out a wide field for speculative reasoning. We have italicised the problematic paragraph for the benefit of our younger readers, who can exercise their ingenuity in determining the precise functions of cog wheels considered as motors, and also in deciding whether it is the drum or the battery which always remains stationary ; whether, in that case, they can be set in motion by a wire and a dynamo ; and, if so, what kind of a battery is it—primary, secondary, tertiary, or what—that necessitates, when the power required is very small, a dynamo and a wire to set it in motion? Perhaps, however, it is the drum. Think it out, will you ?

THE ELECTRIC LIGHT IN PERU.—A prominent merchant of Callao, Peru, is now in Boston on an important mission—the lighting of the great cities of that country with electricity. This gentleman says that many great improvements have been made in the country since he went there ; but, judging from past appearances, the near future will see many more public improvements, perhaps the most modern of which is the introduction of the electric light to the eight principal cities of the country—Lima, Callao, Arequipa, Puno, Cuzco, Trujillo, Cajamarca, and Puira. These cities, or many of them, are lighted at night with antiquated oil lamps, while others are illumined with the densest kind of yellow gas but little better than the oil lamps. This is a consequence of the high price of coal in these places. But water often takes the place of steam, and so it is intended in Peru. Some of these cities, Lima for instance, have ample water supplies for the purpose of running the electric machinery, and this will be duly economised, while in the other cities the light will be greatly improved at but little extra cost. Mr. Widlund and Mr. Macario Llaguno having been granted by the government the exclusive right of introducing electric lighting into the above eight cities for the next twenty years, they went to America to inquire as to the best system to adopt. Mr. Widlund made careful inquiry, and became satisfied that for their purposes the Thomson-Houston light was the best. The Peruvian Electrical Construction and Supply Company was then formed by gentlemen in the neighbourhood of Boston for supplying electric apparatus of the Thomson-Houston class to Peru. The works of the company at Lynn are now busily engaged in preparing the plant of ninety arc lights, with dynamos and boilers complete, for Lima, which is hoped will soon be ready for shipment, to be followed at short intervals by those for the other cities. In all cases iron lamp-posts will be used. The whole of the material for this lighting will go from New England. Mr. Widlund states that the price of gas in Lima is now 3.20 dollars per thousand, and then it is a poor light. The new company, by the terms made with Messrs. Widlund and Llaguno, will be allowed to import all the necessary apparatus free of duty, instead of paying 45 per cent., the usual impost, even the present gas company having to pay that on every lamp it erects.

THE "CASSEL" PROCESS FOR THE TREATMENT OF REFRACTORY GOLD ORES.—This process, which is purely one of chlorination by electricity, seems to bear promise of more satisfactory results than have hitherto been arrived at. The apparatus consists of a drum containing the anodes, formed of very dense carbon rods connected in multiple arc, and an iron vat which constitutes the cathode. Around the circumference of the drum strong asbestos cloth is arranged for the purpose of preventing the ores from reaching the cathode and acting as a filter. Common salt solution, or sea-water and lime, are the only substances used. The gold dissolved by the chlorine is carried by the current to the negative pole into the vat, and is deposited there as a black slime in the metallic form, from whence it can be scraped off and melted. The drum is revolved at the rate of about eight revolutions per minute, so that the ores may be constantly thrown against the anodes, whereby all the particles of gold are brought into most intimate contact with the pole, where the nascent chlorine is generated, and are readily converted into chloride of gold. The chemical action which takes place will be easily understood. Instead of the free gas being separately generated in the ordinary way, the chlorine is evolved in the apparatus in the *nascent* state in contact with the ores, in which condition it has an immensely greater combining capacity for gold. At the same time nascent oxygen is also generated which, oxydising the sulphides, arsenides, &c., liberates the gold, the nascent chloride at once converting it into a terchloride. A secondary reaction then takes place, and hypochlorous acid is formed, which oxydises the pyrites ; hydrochloric acid is also formed, which attacks any iron that may be present, forming a protosalt of that metal. This soluble iron compound precipitates the gold as fast as the chlorine brings it into solution, and thus prevents its extraction. Each drum has a resistance of about 0·3 ohm, the ends of the carbons being coppered, and, as before mentioned, mounted in multiple arc. A current of from 250 to 300 amperes is used. One drum will, we are informed, treat about half a ton of concentrates in 4 hours, or from 2½ to 3 tons in 24 hours. Where a number of drums are used the cathodes (iron tanks) are also connected in multiple arc. The current is supplied by an Oppermann dynamo and a small Elwell-Parker, giving approximately 17,000 watts in all. These, together with the drums and accessory machines, are driven by a 16 horse-power Otto gas engine.

THE EDISON-SWAN LAW SUIT IN GERMANY.—Our contemporary, the *Elektrotechnische Zeitschrift*, seems to be a convenient medium for the circulation of advertisements amongst the members of the society whose organ it is. Its last number contains a fly leaf issued by Mr. C. H. Stearn, the managing director of the Swan United Company, in which the exact legal position and the future policy of the company are thus defined. "The decision obtained by the Edison Company on the 9th of April was to the effect that Messrs. Nagle Brothers should be restrained from working or selling lamps manufactured under Swan's patent, No. 13,071, and it follows, therefore, first, that this verdict only concerns the firm mentioned, but no other parties ; and, secondly, that it only concerns lamps manufactured according to patent, No. 13,071. An appeal has been made, and there are good reasons for believing that the decision will be reversed. Moreover, our present lamps are manufactured only in part under patent No. 13,071, and in other parts under other and totally independent patents. We are therefore convinced that our present lamps do not infringe the Edison patent. We have entered a protest against the validity of this patent in the Supreme Court at Leipzig, and even if the patent should not fall altogether it will be restricted within the limits already assigned to it by the *Patentamt*, and thus the tendency of the Edison Company to establish a monopoly will be checked once for all. We have recently established, in Kalk-on-the-Rhine, that is on German soil, works for the manufacture of our lamps, and we are about to introduce further improvements, which

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will make our lamps absolutely independent of the Edison patent. These new lamps we hope to put on the market within a few months. Inasmuch as the present lawsuits will probably last one or two years, it may be expected that by the time the final decision has been obtained all the present lamps will have been replaced in the natural order of things by our new pattern, but we undertake to replace all the old lamps which might then still be in use if the final decision should fail to upset the present verdict." We cannot but admire the pluck shown by the Swan United Company, and hope they will succeed in breaking down a monopoly which threatens to become a serious obstacle to the development of the electric lighting industry in Germany. It would almost seem as if the company's German connections had instilled into them something of Prince Bismarck's political creed: First tell the world, and your enemies especially, exactly what you mean to do, and secondly, do it.

THE INSTALLATION AT THE THEATRE ROYAL, MADRID.—The following is the result of some experiments conducted by Señor Isidoro Cabanyes with eight series of 50 accumulators each, supplying the current to the 250 incandescent lamps at the Theatre Royal, Madrid :—

$$\text{Per cell} \begin{cases} \text{E.M.F.} = 2{\cdot}35 \text{ volts.} \\ R_i = 0{\cdot}01 \text{ ohm.} \\ \text{Capacity} = 400{,}000 \text{ coulombs.} \end{cases}$$

$$\text{Lamp} \begin{cases} 100 \text{ volts.} \\ 0{\cdot}8 \text{ amperes.} \\ 125 \text{ ohms.} \end{cases} \qquad \text{Battery} \begin{cases} \text{E.M.F.} = 117{\cdot}5 \\ R_i = 0{\cdot}0625 \end{cases}$$

$$\text{Resistance of 250 lamps} = \frac{125}{250} = 0{\cdot}5$$

$$\text{Sum of resistances} = 0{\cdot}5625.$$

$$C = \frac{117{\cdot}5}{0{\cdot}5625 + a} = 250 \times 0{\cdot}8 = 200.$$

$$a = \frac{117{\cdot}5 - 112{\cdot}50}{200} = \frac{5}{200} = 0{\cdot}025.$$

$$T = \frac{g\,k\,.\,(f \times R + n \times R^1)}{f \times n^2}$$

T = time in seconds.
g = acceleration.
k = work (kgms.) of each cell
R = internal resistance of one cell.
n = number of series.
R^1 = resistance of exterior circuit.
E = E.M.F. of each cell.

Applying this formula to an actual case,

$$T = \frac{940{,}000\,.\,(0{\cdot}5 + 8 \times 0{\cdot}525)}{50 \times 5{\cdot}5225}$$

$$= \frac{4{,}418{,}000{,}000}{276{,}125} = 16{,}007'' = 4^h - 27'.$$

The charging of the accumulators was carried out as follows :—The cells were in 4 batteries, each battery being of 4 series of 25 elements, and these were charged in each case by a Gramme dynamo, type A, which, at 850 revolutions per minute, gave a current of 17 to 22 amperes, with a difference of potential at the terminals of 70 to 80 volts, and had an internal resistance of 1·5 ohm. The batteries were made up, as before observed, of 4 series of 25 elements :—

$$\begin{cases} \text{E.M.F.} = 58{\cdot}75 \\ R_i = 0{\cdot}0625 \\ R. = 3{\cdot}00 \\ \qquad \text{additional.} \end{cases}$$

This latter resistance was added for the reason that the best conditions were found when the exterior resistance was nearly double that of the interior.

$$T'' = \frac{g.\,K\,N}{t''.e.c''(1-m)} = \frac{94000000}{58{\cdot}75 \times 22 \times 0{\cdot}9}$$

$$= 80825'' = 22h - 27' \text{ during 24 hours.}$$

The dynamo under these conditions consumed very nearly 3 horse-power. The four dynamos with the respective batteries consumed about 12 horse-power. The total consumption then was $12 \times 24 = 288$ horse-power per hour, equivalent to about 14 steam horse-power during each period of 20 hours.

THE EVOLUTIONARY SQUADRON.—The correspondent of the *Standard* says :—"Bad weather and great darkness will materially assist the enemy, unless Admiral Whyte should decide to remove some of his ships into positions from which their electric lights can sweep the booms and the mine fields beyond. Yet, if the tops of the hills on Bere Island are properly occupied by the defenders, it ought to be difficult for the foe to approach either entrance to the anchorage without betraying themselves. In such circumstances as these in which we find ourselves, portable electric lighting apparatus would be particularly valuable. With good lamps on two or three eminences we might render it impossible for an enemy to surprise us from the sea. At the same time, it would not be easy to transport engines and dynamos to the craggy tops of these desolate hills; and, therefore, it is surely desirable that some means should be devised for the laying of wires from ships lying at an anchorage to points which it might be useful to illuminate. In this manner the existing engines afloat might be utilised in the conduct of operations on shore. On Tuesday various experiments were tried with the object of testing the electric contact mines that form a considerable part of the outer line of defence; and the "Mariner" crossed and recrossed the sections of submarine cylinders laid down by the "Minotaur," "Sultan," "Hercules," "Iron Duke," "Repulse," "Devastation," "Hotspur," "Lord Warden," and "Shannon." No charges were fired, but Menotti instruments were used that gave indication whenever a wire was struck. Only in two cases did these submarine engines fail, and then it was probably because the "Mariner's" draught of water (12ft. only) was too little to disturb them, they being laid at 10ft. below low-water level, and it was about half-tide when the experiment was tried." *The Times* correspondent, writing on the 24th inst., says: "Last night the ships used their electric lights, and the display was very striking. The brilliancy of the beams thrown from the different ships varied very much. Those produced by the old-fashioned Wilde machine were poor indeed when compared with the pencils of the D Grammes. It was noticeable how glaringly conspicuous the three ships which have been painted white, with a view to future service in the tropics, became under the light. One lesson of great practical importance has been taught us already by this assemblage of ships, and that is the absolute necessity that every squadron on active service should possess a Hecla, and, therefore, that a sufficient number of new Heclas should be ordered at once. Whether they ought to carry guns or not, or what alterations or improvements may be made so as to render them more efficient, is a matter of detail; the one important thing is that they should have a liberally-furnished factory capable of executing repairs to torpedoes, boats, engines, and electric light machines. Admiral Hornby is, wisely, extremely reticent as to his intentions, but it was generally understood that the grand attack was to take place to-morrow night. The "Hotspur" is to go outside as a sort of forlorn hope, prepared to sacrifice herself, and endeavour to decoy the enemy into the dangerous neighbourhood of mines that her own superior knowledge will enable her to avoid. She will carry a fixed electric light and be protected by nets. The gunboats also will have both nets and electric lights. The "Mariner" and "Racer" sloops will be considered neutral, but will exhibit electric lights."

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ALTERNATING CURRENTS.

BY THOMAS H. BLAKESLEY, M.A., M. INST. C.E.

(*Continued from page 59.*)

The problem of the transmission of power by means of harmonic currents admits of being readily treated by the geometrical method, in the same fashion as local condensers and induction problems, and as, moreover, some interesting particulars are rendered so plain by the use of geometry as almost to be self-evident, that method will be here adopted.

To give a preliminary notion of the possibility of such an action, imagine an ordinary galvanometer subjected to alternating currents. The impulses on the needle considered as fixed would be as often and as strongly in one direction as in the other. But suppose that after an impulse in one direction the second and contrary impulse is not given *until the needle has passed over the dead point position*, which will be at right angles to the coils. In this case the second impulse will only add to the speed of the needle's rotation. Postpone the third impulse similarly until the second dead point has been passed, and again there will be positive acceleration. This elementary form of the problem enables the possibility of the motion to be conceived. But it does more than this, it shows that the direction of motion of the *receiving* machine is indeterminate. The impulse must be one which tends to throw the poles of the needle to the side of the coils remote from that on which they are when they receive the impulse; but the direction of rotation produced by the impulse simply depends upon which side of the dead point the needle may happen to be. Electric transmission of powers admits, therefore, of the following classification:—

A magneto machine giving a direct current and employed as a driver gives a current varying with its direction.

A similar magneto machine used as a follower takes a direction varying with that of the current.

A dynamo electric machine giving a direct current and used as a driver gives a current whose direction is indeterminate.

A dynamo electric machine used as a follower takes a direction determinate and independent of that of the current.

An alternating machine, whether used as a driver or a follower, may run in either direction indifferently. The period of the follower coincides with that of the driver.

To treat the question more generally and exactly, it must be remembered that in a simple circuit, possessing no capacity, and subject to sources of alternating electromotive force of the same period, we may combine all the electromotive forces into one having that period. Thus if A B, B C, C D, D E, E F, are a number of lines representing in magnitude and phase the various electromotive forces, and A F be joined, then A F is the single electromotive force which will produce the effects observed. If there exist self-induction or mutual induction the diagram can be completed in the manner already indicated in earlier articles, using A F as the single impressed E.M.F. We shall thus obtain a line representing the effective E.M.F., which will be in the same phase as the current. Dividing this by the resistance we can compute the current, and if we multiply the result by the projection upon this line of the line representing any of the individual component electromotive forces, and divide by 2 we shall obtain a measure of the power at work in the particular corresponding source. Now the projection of any individual line will be positive if the angle between it and the line of effective E.M.F. be less than a right angle, and negative if this angle be greater than a right angle.

In the former case the power is positive and the source does work.

In the second case the power is negative, and the source has work done upon it.

Thus in Fig. 14, let A B, B C, C D be the electromotive forces of these sources, laid down in their respective phases. Then A D is the resultant E.M.F.

The angle E D A has its tangent equal to $\frac{L\pi}{TR}$.

Where L is the coefficient of self-induction of the circuit,
R is the resistance,
and T is the half period of the undulation.

A E is at right angles to D E.

From C and B, C C′, B B′ are drawn perpendicular to E D.

The power exerted by source of A B is therefore $\frac{ED}{2R} . EB'$; similarly the power exerted by source of C D is $\frac{ED}{2R} . C'D$.

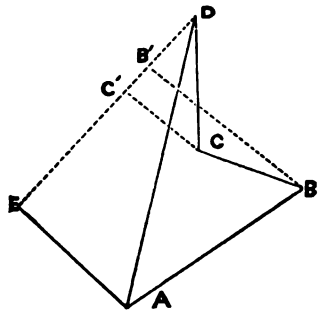

Fig. 14.

But the power of the source of B C is seen in the diagram to be negative. Hence this source has work done upon it with a power equal to $\frac{ED}{2R} . C'B'$.

Such a source would constitute what is called a motor; *i.e.*, it may be loaded in the mechanical sense of the word, and made to do work.

It will be seen that had the coefficient of self-induction been small, and E nearly coincided with A, the projection of B C upon E D would have been positive, and the source of B C would not have been a *recipient* source, but would have had to do part of the work of heating the circuit.

Having settled these preliminary ideas, let us suppose a case where the sources are two in number, represented in magnitude and phase by A B, B C (Fig. 15), of which B C is the smaller; and let A B C be less than $\frac{\pi}{2}$ in the direction of advancement.

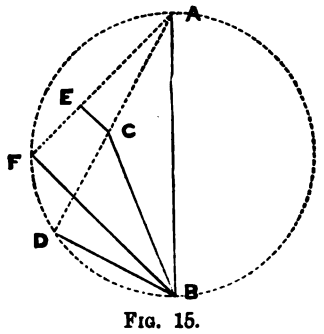

Fig. 15.

Upon A B as diameter describe a circle, and join A C and produce it to cut the circle in D.

From C A in the direction of retardation set off the angle C A F, having a tangent equal to $\frac{L\pi}{TR}$, the line A F cutting the circle in F.

L T and R have the usual significations.

Draw C E perpindicular to A F.

Join B D, B F, which lines will be at right angles to A D, A F, respectively.

Then, calling for brevity the source of A B the source A, and the source of B C the source C, we have

$$\text{The power exerted by Source A} = \frac{AE . AF}{2R}$$

$$\text{The power doing work on Source C} = \frac{AE . FE}{2R}$$

Thus work will be done upon C so long as E lies within the semicircle A F B, upon which F always lies. But if the

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coefficient of self-induction is sufficiently increased the angle D A F will open out, and F will move along the circle towards A until F C B are in one straight line. This condition obtains when L is large enough to satisfy the equation,

$$\frac{L\pi}{TR}\sin\theta = \cos\theta - \frac{f}{e},$$

where θ is the angle A B C, and A B = e, B C = f.

If B C is so great that the point C approaches the circumference, C will for that reason alone cease to be a recipient source, for the projection of B C upon the line of effective E.M.F. will either vanish, if the coefficient of self-induction is evanescent, or be positive if this latter has a finite value, in which case the source C does work.

But suppose that matters are represented actually by Fig. 15, in which the source C is, suppose, loaded to the extent represented by $\frac{FE.EA}{2R}$. There will be a condition of equilibrium, but it is necessary to show that such a position will represent *stable* equilibrium; that is to say, it is necessary for

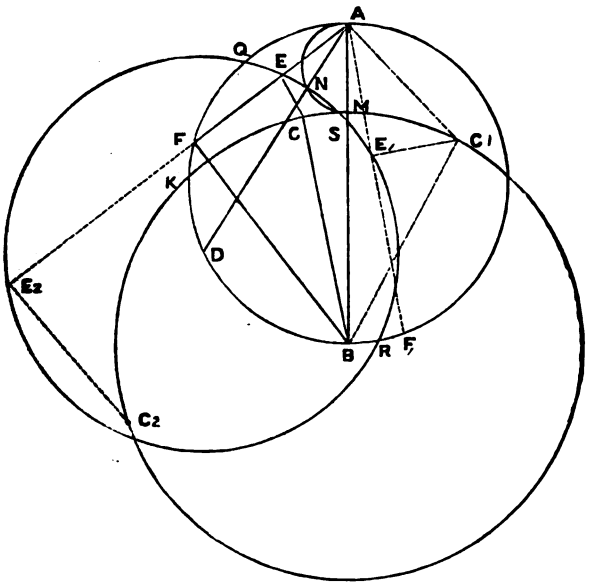

Fig. 16.

steady motion that, if the angle of phase difference C B A be slightly varied, there shall be a restitution of the exact position and not an augmentation of the displacement.

For the consideration of this point we may suppose the phase difference to be the only variable element, the two electromotive forces and the coefficient of self-induction remaining constant.

With a variation of the angle A B C, C evidently describes a circle round B as centre. Now A E always bears the same relation to A C, viz., the cosine of the angle E A C, which remains always the same, since the coefficient of self-induction does so. Therefore, whatever curve C describes round A, E will describe an exactly similar one on a scale diminished as the cosine of the angle E A C.

The curve which E describes will therefore be a circle whose radius is equal to C B cos E A C.

The two circles described by C and E will not, however, be similarly situated with regard to A B, but since E A makes a constant angle with C A, the circle described by E will be displaced in the direction of retardation by the amount of the angle E A C, at the same time that it is diminished, and drawn nearer to A in the proportion of the cosine of this angle.

We thus arrive at the following construction for Fig. 16. A B is the electromotive force of the driving machine. B M is cut off from A B, so that B M represents the electromotive force of the follower in *magnitude* only. M C K is a circle described with B M as radius. B D K is a circle described on A B as diameter. B A D is the angle whose tangent is equal to $\frac{L\pi}{TR}$, and is set off from B A in the direction of retardation. M N A is a circle described upon A M as diameter, and cutting A D in N. S N E Q is a circle described with centre D and radius D N, cutting the circle D B K in Q, and M B in S. Then, since A N : A M :: N D : M B :: cosine D A B : 1, and tan B A D = $\frac{L\pi}{TR}$, from the foregoing considerations the circle S N E Q is the circle described by the point E of Fig. 15.

Now, let B C be some particular position of the E.M.F. of the follower, and E the corresponding point upon the circle whose centre is D.

A E produced cuts the circle B D A in F.

Then the following proportion holds good.

The power exerted by A : power transmitted to C : power expended in circuit :: A F : F E : E A.

Now, suppose a displacement of B C to take place which diminishes the angle A B C—*i.e.*, C is displaced towards M, then evidently E is displaced also towards S; but F is displaced from Q, and therefore A F and F E both become larger.

But A F is proportional to the power exerted by the driver, therefore a greater load is thrown upon the prime mover, and A B will be displaced in the direction of retardation; *i.e.*, the angle C B A will tend to open out again for this reason.

But, further, the power transmitted to C is proportional to F E, and this is increased. The load on C being fixed, and the power being now more than is necessary, the source C will race. Hence, for this reason also, the angle A B C will open out, and regain its original size.

Now, suppose that C is displaced in the direction away from M, which would be the same thing as supposing a retardation of the driver.

In this case A F and F E would both become smaller. Therefore, the prime mover would race, and so A B would advance to close the angle A B C. The source C would have its power cut off, and the load remaining the same B C would be retarded, and again the angle C B A diminished.

Hence such a position would be one of stable equilibrium of the motion.

A position of equilibrium could also exist on the other side of S, as at E_1, C_1 and F_1 being the corresponding positions taken up by C and F respectively, but the equilibrium will be generally unstable.

For let C_1 and E_1 be displaced from M and S, implying a retardation of the follower. The power transmitted to it being proportional to E_1 F_1 will be diminished, and the load remaining the same, an augmentation of the displacement occurs; and the driver tends to race because A F_1 is diminished; therefore again the displacement will be increased.

If the displacement of C_1 and E_1 takes place towards M and S, A F_1 and E_1 F_1 are both increased.

Hence the follower will tend to race, and the driver to slacken in speed, both tending to increase the displacement.

As with a magnetic needle in a field of force there are two positions of equilibrium, one stable, the other unstable; but these points are not (as in the case of the magnetic needle) exactly opposite to one another. On the contrary, the two positions tend to approach each other as the electromotive forces tend to equality, and the angle between their positions is the angle through which the follower may be retarded without permanently upsetting the stability of the motion; but if the displacement exceed this amount, the follower would tend to fall back more and more, and would ultimately come to rest.

There are two positions for E in which no power is transmitted, viz., those which correspond to the points where the two circles S N E Q, B D Q A cut one another, Q and R. If E lies in the section Q S R, power is transmitted to the source C; but if E lie on the other portion of the circle it describes, power is exerted by the source C.

For any direction, A E, there exist generally two points where a line drawn from A cuts the circle S N E Q. Let E and E_2 be such a pair of points.

Let C_2 be the position of C corresponding to E_2.

Now, the power exerted by source A for this position will be $\frac{A E_2 . A F}{2R}$, and that exerted by source C will be

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$\frac{AE_2 . FE_2}{2R}$. The relation of the latter to the former is $\frac{FE_2}{AF}$.

Now, as E_2 moves round from Q to R, on the line QE_2R, the above relation starts from zero, passes by positive values through a maximum value, and ends again at zero. There will therefore be two positions when the relation of the powers has a fixed value, and one of these will be a position of stability, the other unstable. These positions will alternate in the usual way with the cases of equilibrium for *transmission* of power. I apprehend that what Dr. Hopkinson has stated as regards the impossibility of placing working sources in series applies merely to sources of equal electromotive forces. In such a case MQ and N of Fig. 16 coincide with A, and two of the four positions giving $\frac{FE}{FA}$ a fixed value give a value zero to EA. Of the remaining two positions, one corresponding to transmission is stable; the other, where work is done by C, is unstable, and rigid connecting gearing would be required to maintain the motion.

(To be continued.)

IMITATION OF THE PHENOMENA OF ELECTRICITY AND MAGNETISM BY MEANS OF LIQUID OR GASEOUS CURRENTS.*

BY M. C. DECHARME.

(Concluded from page 96.)

It is not difficult to observe the steadiness of the liquid waves. The current of water issuing from a stationary tube vibrates longitudinally in the pipe and in the nozzle; at the moment when it meets the glass plate it spreads in concentric waves due to the resistance which opposes the liquid by friction. The steadiness is explained by the regular and even flow of the liquid.

For the imitation of *electro-chemical multiple rings* by means of continuous currents of water, I employ for each group a flat cylinder (Fig. 4), the lower surface of which is traversed by

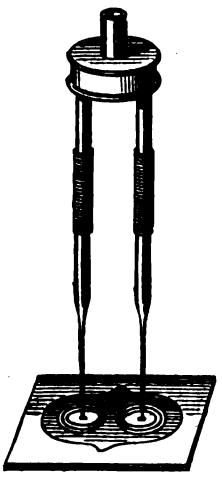

Fig. 4.

two, three, four, &c., parallel tubes, while the upper surface carries a single tube by which the water is admitted. When continuous currents are directed upon the plate of glass by these tubes, which are sufficiently close to permit of their *hydro-dynamic fields* encroaching upon each other, the waves are immediately influenced; they repel each other, are compressed, and confined within narrower limits than before. Figs. 5, 6, and 7 are examples of some of the diverse conformations which occur. It has been remarked that the weaker the liquids and the more moderate the height of the jets the more the forms of the simple or multiple rings approach to those of their electro-chemical prototypes. Near to the ends of the plate of projection, or close to a solid obstacle, the liquid waves, as with electric waves, have a tendency to dispersion or to assimilate themselves to the outlines of the obstacles which are

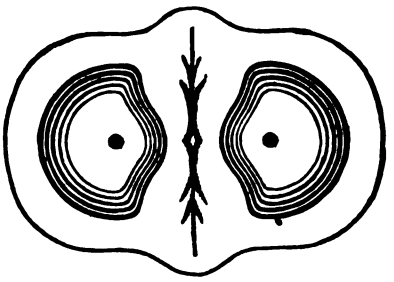

Fig. 5.

opposed to their free development. In the imitation of *bipolar* electro-chemical rings the method of aspiration of the liquid by means of a long syphon (such as, for instance, one of 7^m) may be resorted to, instead of that of the blowing or of the direct

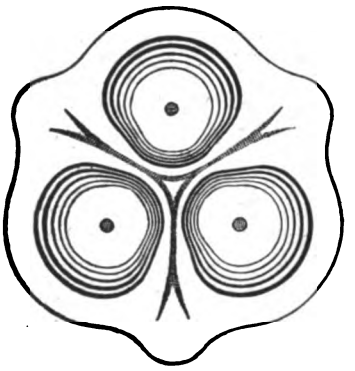

Fig. 6.

flow. Many peculiarities of the electro-chemical rings, such as the want of verticality of the electrodes, the inequality of distance from the points of the plate, the influence of various forms of these, the employ of lineal electrodes, &c., have their

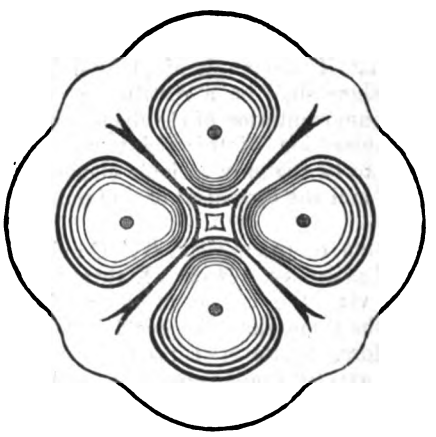

Fig. 7.

analogous effects in the hydro-dynamic rings we have been discussing.

IV. Physiological Effects.—Conclusions.

The instrument which I use to produce these effects I have named the *hydrodiapason*. It consists of a brass tube (of $0^m{\cdot}5$ in length, of $0^m{\cdot}006$ interior diameter, and $0^m{\cdot}001$ thick), bent in U form (Fig. 8.) The centre of one of the curved parts has an opening by which the tube is placed in communication with a nozzle of $0^m{\cdot}014$ interior diameter, screwed to a water pipe alimented by the waters of the town. The other curved part is cut so as to present two openings opposite to each other, and almost in contact. The apparatus may be fixed in any position, or may be held in the hand. As soon

* From the *Journal de Physique.*

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as the current of water is passed through it it acquires a spontaneous and regular movement of vibration.

If the entire apparatus, or only its free ends, be placed in the water, the diapason acts very well, and the experiment is more easily performed. If the hydrodiapason be touched while it is in vibration (the instrument gives out the sound $la = 217$ vibrations per second) a very sensible *shock* will be received. It is a sensation very closely akin to that which is experienced

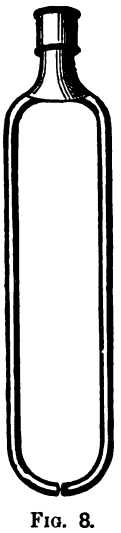

FIG. 8.

when the hands are placed upon the poles of a voltaic apparatus or of an induction coil of small power.

Summary of the Experiments. Comparison of Electric and Liquid Currents.—The phenomena of attraction, repulsion, and vibration which I have obtained with liquids in imitating the effects of electro-magnetism and of induction can also be produced with gaseous currents under more or less pressure. The greater number of the phenomena of static electricity can be imitated equally well with gaseous as with liquid currents; and, finally, the electro-chemical rings may either be produced by currents of air or by liquids, as in the preceding examples. It is not difficult to compare an electric current with a current of water flowing from a reservoir placed at a given height. Many fundamental laws are equally applicable to the two orders of phenomena. Ohm's formula $C = \frac{E}{R}$, which expresses the law of the electric flow, expresses also that of the flow of a liquid. The rapidity of the transmission of pressure in liquids is more especially comparable with the action which takes place with electric currents; the hydraulic telegraph of M. Tommasi has given ample proof of this. In a word, the laws of the propagation of electricity in the *variable period* and in the *permanent state* are analagous to those of the flow of liquids. The laws of derived currents are also common to the two orders of phenomena. In fact the electric current may, in very many cases, be regarded as the movement of an incompressible fluid obeying mechanical laws. The higher the E.M.F. of the current the more the effects which it produces approach in similarity to those of a liquid current.

When an electric current passes from a metallic conductor of large section to a fine wire, it heats the latter, turns it red, and finally volatilises it.

When a liquid current of high pressure passes from a large tube to another which is flexible and narrow (such as an india rubber tube of $5^{mm.}$ in diameter and $1^{mm.}$ thick), it tends to distend, twist, and finally to burst it. The analogy between these two effects are self-evident.

Conclusions.—After having initiated by means of gaseous or liquid currents, in a great variety of experiments, the principal phenomena of electro-magnetism, induction, electro-chemistry, and electro-physiology, I feel that I have some reason for my conclusions upon the analogy of the effects and the analogy of the causes, and for believing that electric and magnetic phenomena are closely allied to hydro-dynamic phenomena—that is to say, that electricity in the form of a *current* (of ether or of ponderable matter) is analogous to a liquid current.

LEGAL.

The Queen v. the Postmaster-General.

This was an application on the part of the Great Western Railway Company for a mandamus to the Postmaster-General to take proceedings to compensate them for the use by him of one of their subordinate lines (the Llynvi and Ogmore) for the purposes of the telegraph. In 1864 the Electric Telegraph Company agreed for fourteen years to construct and maintain telegraphs and keep up telegraphic communication on the Llynvi and Ogmore Railway, to be used for public purposes by the telegraph company and for railway messages by the railway company. The question turned upon the effect of an agreement, providing that the Postmaster-General might acquire the telegraph undertakings of railway companies, on certain terms of compensation, and that "the railway company might at any time require the Postmaster-General to extend the provisions of the agreement so as to include any present or future lines leased or worked by them, if they should make arrangements to that effect with the owners of those lines, but subject to any agreements theretofore made between the owners of such lines and the Postmaster-General." Then it was provided that the Postmaster-General should pay the "railway company certain sums by way of compensation, as twenty years' purchase of the amount of the net annual profits of telegraphs over the wires of the railway company," and in 1882 the Great Western Railway Company also claimed payment, by way of compensation, of sums amounting to about £22,000, and also a yearly rent of £1. 3s. per mile per wire, with arrears. The Postmaster-General refused to entertain the claim, on the ground that that there was no such agreement in existence as could be a subject of compensation under the agreement of 1868, and hence this application.

Mr. Justice MATHEW read a written judgment in favour of the Postmaster-General. The question, he said, for our determination is whether the agreement of 1868 can be treated as having extended to the Llynvi and Ogmore lines. The main purpose of that agreement seems to have been to provide for the performance of the duties which would devolve on the Postmaster-General upon the transfer to him of the undertakings of the Electric Telegraph Company under the contracts entered into. The lines specified were all lines which were the subject of existing telegraph contracts. The agreement did not apply, and was not intended to apply, to any line to be afterwards constructed by the Great Western Railway Company, and the reason seems plain. Such a line would not be one in respect of which the Postmaster-General would come under any obligation by reason of the transfer to him of telegraph undertakings, and would, therefore, not be within the scope of the agreement. Under the agreement it was to be extended to "present or future lines leased or worked by the railway company, if they made arrangements to that effect with the owners of those line." What were those "arrangements?" We do not doubt they were those which would be indispensable in order that the agreement should apply, viz.:—(1) That the owners of the lines should accept the Great Western Railway Company as contractors with them for the telegraph service of their lines; and (2) that they should adopt the terms of the agreement of 1868 in lieu of the terms of any former contracts with telegraph companies. If this view of the meaning of the contract be correct, it seems clear that the Great Western Railway Company are wrong in their contention that the agreement can be made to extend to the Llynvi and Ogmore lines. Down to the expiration of the respective periods of 14 years (if the contracts had not ended at an earlier period) the Postmaster-General would seem to have been liable for the performance of these contracts to the Llynvi and Ogmore Company. When the contract ended or expired, the Postmaster-General was free to make a fresh contract either with the Llynvi and Ogmore Company or with the Great Western Company, and some temporary arrangement was, in point of fact, made for working the telegraphs on the Llynvi and Ogmore lines by the Great Western Company. In the absence of any definite agreement, the Llynvi and Ogmore Company, or, it may be, the Great Western Railway Company, would be entitled in accordance with the contracts to use these telegraphs for railway messages—to require the Postmaster-General to remove from the lines any telegraph apparatus used exclusively for public purposes. No steps were taken to compel their removal, nor was any demand made against the Postmaster-General for compensation until 1882, when the contracts had for some time expired. It does not appear that the arrangements between the two railway companies were such as were contemplated by the agreement of 1868. There was not in 1882 any such subsisting agreement for telegraph purposes in respect of the Llynvi and Ogmore lines as would give rise to any legal claims against the Postmaster-General. On this ground we think that there could have been no extension of the agrement of 1868 to the Llynvi and Ogmore lines. We also think that if the supposed arrangement had been made with the Llynvi and Ogmore Company before the expiration of the agreements, the extension of the contract could not have been made so as to give the Great Western Railway Company any right to the compensation now claimed. The contracts could not have been made the subject of a claim for compensation under the Act of 1868, and the agreement, it appears to us, was not intended to have any wider scope than the statute. The agreement of 1868 appears to us to have been incapable of being applied except (1) where there was subsisting contracts with telegraph companies, and (2) where those contracts conferred upon the railway company the right to be compensated as provided by that agreement. The agreements between the Llynvi and Ogmore Company and the Telegraph Company were not of this character, as they conferred no right on the company to carry on the business of transmitting messages for money.—Rule therefore discharged with costs.

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THE ELECTRICIAN.

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ELECTRICITY AND LIGHTHOUSES.

That the application of electricity to the purposes of lighthouse illumination and for connecting lightships with the mainland occupied so prominent a place in the speeches at the Trinity House banquet is a fact highly complimentary to electrical science, and very encouraging to electrical engineers. The two great practical questions of providing lighthouses with the most powerful of all illuminants, and of establishing telegraphic communication with lightships, may still be said to be in their experimental stage; but there is reasonable ground for anticipating that in due time they will be answered satisfactorily. The Trinity House has not yet completed its report on the exhaustive investigations which have been recently made to test the relative value of different illuminants for lighthouses—that is to say, of gas, oil, and electric light; but we may confidently predict that for certain positions, and under given conditions, the latter will be pronounced superior to either of its rivals. For climatic reasons it would seem that this method of illuminating lighthouses has made greater progress on foreign stations than on our own fog-bound shores; but even here the London Trinity Board alone have five such seafarers' beacons lighted by electricity; and the most recent of them, the St. Catherine's Lighthouse, in the Isle of Wight, now nearly completed, will possess the most powerful electric light in the world. It is needless, in the face of these facts, to enter into the vexed question of the penetrating quality of the electric light. The ancient corporation at whose hospitable board the Duke of Edinburgh presided the other evening is undoubtedly the most influential body of the kind in existence; their authority is appealed to, if not enforced, as his Royal Highness observed, throughout the whole maritime world; and it is not probable that they would take the responsibility of adopting the electric light for highly important positions if it did not possess substantial and unquestionable superiority. There are obvious reasons for not altering the character of old established lights; but as the conscience of every seafaring nation is quickened by the increase of sea-going traffic, the necessity for multiplying these safeguards against disaster is more and more recognised, and the claims of the electric light for all new erections are not likely to be overlooked.

A similar humane motive has latterly prompted the desire to establish communication between the shore and the lightships, great numbers of which are located within short distances of land, but which have no sure means in bad weather of instantaneously signalling for help when it is most needed. Lightships are moored exactly at those spots where the danger is greatest, and where in point of fact the greatest number of accidents do occur to vessels that are within sight of land. The lightship service itself is one of no small danger, the vessel being frequently fouled and sometimes sunk either by stress of weather or by what the Duke of Edinburgh in nautical phraseology called close shaving. Obviously it is desirable to resort to the telegraph to inform the nearest lifeboat station as to any disaster observed from the deck of the light vessel not visible to the lookout men on shore, its precise nature and its exact locality. Signal rockets supply such information but very inadequately, and in unfavourable weather not at all. Full and rapid information, independently of time and season, would often be the means of rescuing many precious lives, to say nothing of the saving of much valuable property. The expense of establishing such a system and of maintaining it, we may be sure, would be quite a secondary consideration if the thing were practicable. But it must be confessed that there are great difficulties to be encountered and many curious problems to be solved which the general public are little aware of. We pointed out last December that the light ships, though moored generally in comparatively shallow water, are obliged to have their cables payed out to allow for rise of tide and rough weather, so that the vessels swing easy at all times. In this way they often describe a circle of considerable dimensions; and on this account if no other it would be impossible to attach a submarine cable in the usual way, or indeed to have it separately attached at all.

One or more ingenious contrivances were invented to admit of the telegraph cable twisting and turning as much as it pleased, theoretically, without getting kinked or losing electrical continuity; bnt it soon became evident that even if the telegraph cable thus accommodated could take care of itself if left to itself, it would instantly come to grief if the ship's cable fell foul of it, which was sure to happen the first time the ship swung round. Hence it was decided that the two cables must somehow be combined; and, after a lengthened preliminary series of experiments at their works, the Telegraph Construction and Maintenance Company devised a cable which was to serve the double purpose of mooring the lightship and connecting it electrically with a submarine telegraph cable proceeding from the anchorage in the usual way to shore. A hollow steel wire rope, 8½in. in circumference, formed by fourteen twisted strands, was ultimately adopted. This rope, which took the place of the chain cable attached to the anchor, was capable of bearing a strain of 70 tons, and had the insulated telegraph wire running through its centre. The efficiency of this device was tried, as our readers are aware, six months ago, on what is called the "Sunk" lightship, situated about nine miles off Walton-on-the-Naze, from which place instant communication with Harwich and the neighbouring lifeboat

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stations can be kept up. The experiment, which may be called a speculative one, inasmuch as no payment was to be made in case of failure, proved highly encouraging. Since the beginning of March the Sunk lightship has been in telegraphic communication with the shore, and we hear of no difficulties in maintaining it that are likely to be insurmountable. As the Duke of Edinburgh observed, we cannot yet be positive that all the difficulties attending such undertakings will everywhere be overcome; but a good beginning has been made, and the country, as well as the enterprising firm who are entitled to the credit of it, may be heartily congratulated on the prospects of this most beneficent work.

CORRESPONDENCE.

SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The fact that the Miller Prize has been awarded by the Council of the Institution of Civil Engineers to Mr. F. G. Howard, for his paper on "Secondary Batteries," attaches to that communication a certain importance. Students will regard it as the latest information on the subject; but it appears that the author is not well acquainted with the latest forms of secondary batteries, nor with their recent applications. I do not wish to depreciate the value of the paper, which in many points is exceedingly interesting and instructive, but I wonder why Mr. Howard finished off with a period (the Vienna Exhibition of 1883) when secondary batteries, and especially their applications, were so little understood.

It behoves those who have gained experience with these appliances since Mr. Howard relinquished the task of making notes on the progress of certain types of cells to supplement the information supplied at the students' meeting of the institution a few months ago; there are, moreover, several statements which require modification or explanation. Taking them in consecutive order, we find first a table giving the "Storage capacity of various secondary batteries as regards ratio of work to weight," and then stands a "theoretically perfect" cell with a storage capacity of 360,000 foot-pounds with the highest percentage of efficiency = 100.

We know that the energy evolved by the oxidation of a pound of lead is equivalent to 360,000 foot-pounds, but we cannot conceive an ideal *battery* where, even if every atom be active, that amount of work could be put in. The comparison of efficiency thus established is not a happy one, and it is misleading; the batteries referred to in that table are all made of lead, and if the comparison or the "efficiency" refers to a peculiar arrangement of the materials the "theoretically perfect" cell should be left out, and instead of "efficiency" call it relative capacity, or establish a coefficient if such were deemed useful.

Mr. Howard states, and others have said, that "the advantages of accumulators made after the Planté type over those of the Faure type are that they afford a far higher rate of discharge. This property is invaluable for many purposes, as, for instance, where numerous lamps are required to be run for only a short time." By Faure type, I presume is meant a battery with lead oxides. It would be exceedingly interesting to know whether the two types referred to have ever been discharged side by side, say supplying 100 lamps for half an hour, two batteries of equal weight discharging at the same rate.

As regards the durability of the Sellon-Volckmar type and the effect of overcharging the author seems ill-informed; at any rate the batteries made by the Storage Company within the last twelve months have given great satisfaction, of which fact anyone could satisfy himself with very little trouble. With properly constructed batteries this overcharging is not such a serious matter as is generally supposed.

Why should the Planté accumulator arrive at its "maximum efficiency" when "it is on the point of falling to pieces?" The Planté plate has its highest *storage capacity* when it gets thoroughly disintegrated; but surely the *efficiency* has nothing to do with the period of existence.

Mr. Howard advises his audience to test the cells from time to time "by taking a short length of stout wire, holding one end upon one pole of the cell to be tested, and striking the opposite pole with the other end of the wire." This is an old-fashioned, clumsy, and, to novices, dangerous method. The proper way is to use a low constant voltmeter or a detector, and observe the deflection of the needle upon a scale, taking one cell at a time. Thereby we can see not only whether the cell is *quite* discharged, but also whether the E.M.F. is low, and, further, whether a reversal has taken place in any one cell, in which case the needle will deflect the wrong way relatively to the terminals of the plates.

With regard to the employment of secondary batteries for tram cars and boats, I may state that there has been more real practical work done *since* 1883, where Mr. Howard leaves off, than at any previous time.

The "Electricity," which was launched in 1882, has been altered in the spring, 1883, by taking the counteshaft out, and running the screw direct from the armature of the motor. This was considered impracticable by marine engineers, and Messrs. Yarrow and Co. could only be convinced of the efficiency of the working of a high speed propeller after I had completed a series of experiments, when they adopted the same plan in the Vienna launch. This I mention because Messrs. Yarrow and Co. receive generally the credit for this innovation.

The electric launch, "Australia," has been in successful operation since last summer, and her cells, which have had a fair amount of work to do, have not cost their owners one penny for repairs; they are still in perfect order, as well as the motor. Whereas the motor in the launch, "Electricity," weighed 658lbs., and took 46 amperes with 90 volts, the motor of the "Australia" (a slightly larger boat) weighs 390lbs., and absorbed 36 amperes with 100 volts at the same rate of speed of boat.

Electric launches of different sizes are now in course of construction.

Great activity has been shown in the development of electric tram cars during the last year. The car which has been described in your journal in December last has had severe tests since the beginning of October, partly on that stiff line at Millwall, and partly at Battersea. The difference between this car and the one mentioned by Mr. Howard is very great. The new accumulators weigh and measure just one half of the former; the motor also absorbs one half the current for the same speed of car.

The tram car cells contain 26lb. (each) of lead plates; they are charged at the rate of 32 amperes, and discharged at an average rate of 46 amperes; mounting stiff inclines they give 100 to 150 amperes, on the level 30 to 35 amperes with loaded car. These cells have been working for eight months and they are still in splendid condition—it would do Mr. Howard good to see them. When the car is not running these cells are kept at work for other purposes, in order to ascertain their durability. Another tram car of exactly similar design to this last one has just been shipped to Cologne, and there are signs which encourage the idea that electric propulsion by means of secondary batteries will receive a practical development on the continents of Europe and America before certain prejudices and red tapeism in this country will be overcome.

If Mr. Howard chooses to read another paper on the same subject he will find ample new material, and I am sure he will receive plenty of information for the mere asking for it, and he will be invited to make his own observations if it is for the purpose of instructing those who still look upon secondary batteries as laboratory toys.—Yours, &c.,

A. RECKENZAUN.

60, Queen Victoria-street, E.C., 20th June, 1885.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I fear that many outsiders reading Mr. G. Howard's paper upon secondary batteries will jump too readily at the

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conclusion that they are "hopeless," an impression which I am sure the author had no intention of conveying, being himself, I venture to think, a full believer in them. He has not, it is true, called in question their convenience, their economy, and, under very many conditions, their indispensability; but the conclusion which might be deduced from his statement as to their durability over-rides all these considerations, and if not modified might, to some extent, stand in the way of their general employment.

In Mr. Howard's experience one of two things must have occurred—either the batteries upon which he bases his statement were very badly made, or they were very badly used. In either case the period of their life may have been as readily but a few weeks, or even days, as the few months he accords to them. Unfortunately there is no doubt that many of the batteries constructed at a certain period by the chief manufacturing company, as also by other persons, were seriously defective in one or more points. Imperfect formation, bad connections, unsound containers, disproportion to the work for which they were to be applied, were faults consequent upon carelessness and inexperience, and all these elements have played their part in bringing about untoward results. But such mishaps, however occasioned, have no real bearing upon their practical usefulness or otherwise, and it would be not only unjust to those interested, but unfortunate as regards scientific and industrial progress, if preventable causes are taken into account in considering the abstract principles of utility and success.

I should have been delighted had Mr. Howard favoured me with a few inquiries before dealing so summarily with a subject of vast scientific and commercial importance, and I could, I venture to think, have resolved many doubts he appears to entertain, and convinced him that sufficient time has not as yet elapsed since the employment of the forms of secondary batteries to which he alludes to arrive at any accurate data for estimating their length of life.

So far as the forms in which I am interested are concerned, no failure has come under my notice which has not on investigation been satisfactorily accounted for. I say satisfactorily, in the sense of having been proved to have arisen from remediable causes entirely unconnected with the principle involved. I can show Mr. Howard cells which, with the exception of occasional intervals of a few weeks, have been in full and regular work since they were first manufactured under my specification before any commercial development took place, viz., the spring of 1882, a period of three full years, and their present still perfect condition warrants the assumption that they will do duty for as many years more. *Care in manufacture and ordinary attention to rules for working are all that is essential to make this a normal condition*, and the evils of buckling, of undue sulphating, of short-circuiting, and of local action (the latter causing the separation of the active material from the conducting frame or support) need never occur, and should now be things of the past.

I will not at present further encroach upon your space to touch upon some points in Mr. Howard's paper which are open to remark, such as his suggested mode of testing, &c., but I would wish to remove the impression he conveys that "skilled" supervision is necessary. Intending installers of the electric light might be unduly influenced against its adoption if they supposed that they must keep an electrician on the premises. My experience over some years is that once installed on right principles and under competent supervision, there is nothing in the working of the electric light either in respect of the engine, the dynamo, or the accumulators which is beyond the capacity of an under gardener or labourer of average intelligence, after a few days' training.

The work and anxiety to those engaged (whether as amateurs or commercially) in pressing forward the introduction of electric light has indeed been an up-hill one, and now that the initiatory labour is, it may be hoped, drawing to a successful issue, and the practical and beneficial results within measurable distance, it would be disheartening if any purely imaginary difficulties are raised as bugbears, which cannot fail to retard its development.

With regard to the immense employment which is in prospect for electrical accumulators, my views have been pretty generally known, and as time passes they are, I am happy to say, being slowly but surely justified and confirmed. Already most of my friends, some of them distinguished electricians—who in the early days good-naturedly laughed at my enthusiasm and confidence in their ultimate success—freely recognise and admit their necessity, and the important part which they are destined to play in the great commercial industries now rapidly growing out of the utilisation of electricity.—Yours, &c.,

JOHN S. SELLON.

The Hall, Sydenham, 24th June, 1885.

NOMINAL CANDLE-POWER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The Philadelphia report on arc lamps appears at first sight to give information on an important point on which hardly any published statements have been made, viz., the relation between electric energy and the light of arc lamps.

In the early days enthusiastic companies measured the light concentrated in one direction, with carbons out of line, as is done with a search light, and called this the nominal candle-power. The figures 1,200 and 2,000 opposite the name Brush appear to be relics of these times.

We were recently asked to estimate for some 25 arc light dynamos to give lights of 3,000 candle-power, with an 8-ampere current, and on expressing a preference to designate the out-put by the amperes rather than by the candle-power were told that nominal candle-power was meant; it therefore appears quite time that some definite knowledge should exist on this point.

The report is, however, very disappointing, and it does not add much to our scanty knowledge. Examining it by the aid of the graphical method, plotting current as ordinates, and candle-power as abscissæ, and taking the 45 deg. ray in each case, the points are scattered like stars. The two Brush lamps, and the two Van de Poeles seem to lie on lines of their own, passing through a point somewhere in the neighbourhood of the origin of co-ordinates; but the others are anywhere, though the diversity of the volts would not lead one to expect much regularity.

Plotting watts against candle-power gives hardly any better result; neglecting Arago and the Western Company, the rest seem at first sight to lie somewhere round the line of 1,000 candle-power to the kilowatt, or 0·5 watt to the candle.

In a recent conversation with one of the first electric engineers of the day, he gave his opinion that 10 amperes should give about 1,000 candle-power, and 20 amperes 3,000 candle power. Taking 12 amperes at the mean volts (neglecting the Western Company), say 42, which means a rather longer arc than is usual, 1,000 candle-power should be given at 45 deg. On closer inspection of the various measurements, omitting the 1,200 candle-power Brush and the two already mentioned, a curve of $\text{candle-power} = \frac{\text{watts}^2}{300}$ appears to satisfy them fairly. With 950 watts, say 43 volts and 22 amperes, this formula gives 3,000 candle-power, which is singularly near the estimate given above.

A trial of different kinds of carbons is a much easier matter than photometric measurement, and they seem to affect the colour and steadiness of the light much more than its intensity. As long as a carbon gives a good white light and does not form mushrooms or ash, and does not burn away at an extravagant rate, there does not appear much to choose among the well known brands.

It is very satisfactory to find that the distribution of the light in different lamps is so nearly the same, but the information given by the measurements would be far more valuable had the diameter of the carbons and the length of the arcs been given. There are not enough data to show whether the long arcs give a less concentrated distribution or not. It would be interesting to hear more about Richter and Diehl. The former appears not to have been tested at its best angle; they both give an unusual distribution with a fair efficiency.

This subject of the power of arc lamps is one in which the

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public is at our mercy. Very few people who have bought an electric light plant for arc lights would take the trouble to measure their candle-power, and they would not be much the wiser if they did. But there ought to be some fair guide as to what is a 300 candle-power arc and what is a 3,000 candle-power. The matter cannot well be taken up by any scientific society as at present constituted, and we have no Franklin Institute, though there is more than one educational establishment that should be able to carry out the requisite tests and lay them before the scientific world.

In the meantime, sir, a practical discussion in your columns would help to enlighten both electrical engineers and their clients.—Yours, &c., ALEX. P. TROTTER.

Halifax, 20th June, 1885.

ON AN UNEXPECTED SOURCE OF ERROR IN TAKING GALVANOMETRIC READINGS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: When engaged lately in testing the E.M.F. of several cells by means of a coil of very high resistance and one of Sir William Thomson's magnetometers, I was puzzled to find that the results did not properly agree with each other. My general practice was to get into position so that the index covered its reflection in the mirror below just when pressing down the key which allowed the current to pass through the coil. But on one occasion I happened to draw back from the magnetometer and again approach it when the needle was at rest, and was surprised to see it move. I searched my pockets to make sure that I had nothing magnetic there; but everything had been laid aside. I then caused various parts of my clothing to approach the needle in case there might be something concealed in the lining; but I got no response till I put my head near it. As I did not think my head was likely to be magnetic, although in my first surprise I actually tried it, I took off my hat, and found that it pulled the needle a good many degrees from zero. I found also that my hat had well-defined poles—the front repelling the N seeking end of magnets, and the back attracting them. It was an ordinary round felt had. On closely examining it, I found that a small steel wire was sewn into the brim to stiffen it. I imagine that many electricians are not aware of this. An interesting question was raised by the result of trying a number of hats. One had no wire and no action. All the rest acted, but the surprising thing was that all the hats, although worn by different people, and bought in different shops, were similarly polarised. All the fronts were N seeking poles. The first thing that naturally occurred to one was to wonder if it could be possible that the magnetisation was produced by the heads which wore them; but I came to the conclusion that the explanation was much more commonplace. Nearly everybody on taking off his hat hangs it up with the front side down. When you grip the hat by the front, and the peg is above you, it is the easiest way. And so the earth's influence develops the observed polarity. But I cannot dogmatise on this interesting subject, as my experiments were few and rough, and made on the "spur of the moment." My object in writing is to warn others to take off their hats when using magnetometers.—Yours, &c., JNO. M. M. MUNRO.

BLIND MATHEMATICS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I see that I must lead your correspondent back to Ohm's law. E in this law indicates *solely* the difference of potential between the ends of a resistance, R, carrying a current, C, and not any E.M.F. in the same circuit acting outside this resistance. Hence it has the same meaning in the heat formula in question.

Single out from any working circuit a part of it having resistance R. A definite difference of potential, E, will exist between its ends, and the current through it be $\frac{E}{R}$. The heat or work developed per second in it is either $C^2 R$, $\frac{E^2}{R}$, or C E; the last two obtained by substituting values of C and R from Ohm's law.

Which shall we use? *Any one*, but for simplicity we select that which includes the data available. Do we therefore "abandon" the other two and treat them as false? Nothing more absurd. Take instances.

You require to know the energy absorbed, (1) in the main and return leads between a dynamo and a system of lamps. You have an ammeter in the circuit, and you know the resistance of the leads. Which is the readiest expression to use? $C^2 R$.

(2). In some portion of a circuit in which no ammeter is placed, or where it may be inconvenient to place one, such as the shunt coil either of an arc lamp or a shunt machine. Nothing is simpler than to use your voltmeter and $\frac{E^2}{R}$.

(3). In an arc lamp do we know the resistance of the arc *per se*? No; it depends on the regulation. What is easier than to read off the current in the main circuit, taking a simultaneous reading at the lamp terminals with the voltmeter and employing C E?

Many other instances occur in practice.

$\frac{E^2}{R}$ is applicable, of course, to the two wires in series, E being, as defined above, the differences of potential at their respective ends, which for the platinum is six times the silver, whatever current. But it is simpler to use $C^2 R$ here. Should $\frac{E^2}{R}$ be therefore shelved as useless? Certainly not, as the above instances show. We see also that resistance favours heating under some conditions, while it hinders it under others. These conditions must not be ignored.

I trust this will suffice to convince Mr. Williams of the exactness and utility of these expressions, thus sparing any further space being occupied under the above heading.—Yours, &c., H. D. WILKINSON.

School of Electrical Engineering,
Hanover-square, W.

THE NEW CABLE SHIP "BRITANNIA."

On Tuesday last, at the invitation of the Telegraph Construction and Maintenance Company, a number of gentlemen interested in submarine telegraphy visited Greenwich to inspect the new ss. "Britannia," recently built for the company by Messrs. Laird, of Birkenhead, and now lying off the Company's wharf at Greenwich. Among the guests may be noticed the following gentlemen:—

The Directors of the Telegraph Construction and Maintenance Company:—Sir Daniell Gooch, Bart., M.P.; Lord Alfred Paget, Sir George Elliott, Bart., M.P.; Vice-Admiral Sir George H. Richards, F.R.S.; Mr. G. W. Campbell, and Mr. Philip Rawson.

The Maharajah of Johore and suite, Prince Khalid, Inchi Abdul Rahman, and Inchi Abdullah.

Lord Hawke, Admiral Sir H. Keppel, G.C.B.; Mr. Pender, M.P.; Sir James Anderson, Sir William M'Arthur, M.P.; Hon. W. St. John Brodrick, M.P.; Count Oscar Von Reichenbach, Mr. Patey, Mr. W. Ford, Mr. W. Barber, Mr. John Collett (Director of Contracts, Admiralty); Mr. W. S. Baughan, C.B. (Director of Transports); Mr. C. W. Stronge, C.B.; Mr. Cyrus W. Field, Mr. D. H. Goodsall, Mr. Graves, Mr. Preece, Mr. Youle, Mr. Shuter, Captain Halpin, Mr. Willoughby Smith, Mr. Clifford, Mr. Nielsen, Mr. Latimer Clark, M.I.C.E.; Mr. H. C. Forde, M.I.C.E.; Mr. Herbert Taylor, Mr. Floersheim, Mr. Schott, Mr. John Laird, Mr. H. W. Jewesbury, Mr. D. Jewesbury, Mr. Draper, Mr. R. Cunningham, Mr. Cracknell, Superintendent of Telegraphs, N. S. Wales; Mr. Todd, Postmaster-General, South Australia; Mr. W. C. Johnson, Mr. S. Phillips, Mr. F. E. Hesse, Dr. Allchin, Mr. John Temple, Mr. Kenneth Anderson, Mr. H. Weaver, Mr. G. G. Nicol, Mr. T. Fuller, Mr. Henry Dover, Mr. Payton, Mr. Lucas, Mr. Dickens, Captain Manning, Captain Cato, Mr. Saunders, Mr. R. Collett, Mr. J. W. Fuller, &c.

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Many of the guests met together at the Old Swan Pier, London Bridge, and proceeded to Greenwich in a special steamboat, which drew alongside of the new ss. "Britannia." This vessel presented a very pretty view from the water. She is built of steel of full iron scantling, by Messrs. Laird, of Birkenhead, has a length of 240ft., with a beam of 34ft., and a measurement of about 1,500 tons. She has twin screws, driven by two pairs of compound surface condensing engines of 1,300 horse-power, also built by Messrs. Laird. On her trial trip, with the engines developing 1,370 horse-power, she made an average of 12½ knots. She has a flush deck, and has three cable tanks, two forward and one aft the engines. The decks are of steel, covered with teak. The vessel carries Kirkaldy's condensing apparatus, similar to that on board the "Calabria" and "Kangaroo," so that if necessary 6,000 gallons of fresh water can be condensed per day. There are three water-tight bulkheads, according to the requirements of the Board of Trade. She also carries water ballast tanks, with a capacity of about 350 tons. The masts and yards are of steel. The arrangements for the comfort of the crew are very good, but the fittings throughout the ship are plain, and are so arranged that with the utmost facility they can be removed, and the skin of the ship got to. The saloon is fitted with polished Dantzic oak, with teak panels, &c. In place of the usual swinging trays, it is fitted with a handsome sideboard with cupboards to answer instead of such trays, and with fixed revolving chairs. The cabins are fitted with iron-framed berths having steel spring bottoms, and, in fact, throughout, every effort has been made to obtain a maximum of comfort without ornateness or expense. The boats are six in number, diagonally built and specially fitted for cable work with Clarkson's patent flotation and Liardet's patent disengaging gear. The vessel has been designed throughout by Captain Halpin, somewhat on the lines of the "Scotia," with all the improvements that experience has suggested, and there is no doubt that he must be credited with having obtained one of the best adapted vessels afloat for the particular work for which it is designed. The "Britannia" is now anchored off the Telegraph Construction and Maintenance Company's Works, in order to be fitted with cable gear and the apparatus necessary for cable work. She will carry picking up and laying down gear, the whole of which will be manufactured by the Telegraph Construction and Maintenance Company. The whole gear, in fact, will be of that company's own manufacture.

After the inspection of the "Britannia" the company went on board the "Seine," where an excellent lunch had been provided under the direction of the proprietor of the Ship Hotel at Greenwich. We may here remark that the "Seine" has been taking on board the duplicate cable manufactured by the company for the Zanzibar and Mozambique section of the South-East African Cable Company. The "Seine" is expected to sail shortly. This duplicate section will probably be laid about August next. Many of our readers will recollect that faults have developed in this section under peculiar circumstances, and an effort is now being made to remedy any future breakdown by duplicating the cable, the new cable being laid much further out at sea.

The principal toasts at the luncheon were "The Queen," "The Builders of the 'Britannia'"—responded to by Mr. Laird—"The Maharajah"—responded to by the Maharajah of Johore in the soft breathing words of the Malayan tongue—and "The Cable Companies"—responded to by Mr. John Pender, M.P.

ELECTRICAL GYMNASTICS.—An electric dumb-bell has been devised with the view of effecting a stimulation of the nerves simultaneously with the exercise of the muscles. It is said that when holding the electrodes in the hands quietly the most marked contraction is generally produced in the muscles of the forearm. When, however, the arm is moved about, as in dumb-bell exercises, the result is a constant change in the effect upon the muscles, all of which are more or less affected according to the position of the arm. This result is obtained by enclosing an induction coil and battery within the dumb-bell, so that it performs the functions of both muscular and nervous stimulator at the same time.

ON THE CALCULATION OF MAINS FOR THE DISTRIBUTION OF ELECTRICITY.*

BY W. H. SNELL, ASSOCIATE.

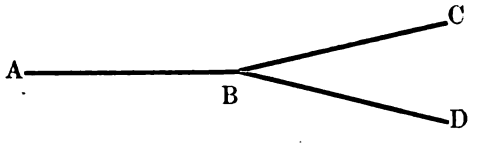
(Continued from page 104.)

ERRATA.—On page 104, second line from the bottom, the formula should read

$$N_1 = \sqrt{\frac{n^2 t_1}{T}} \text{ and } N_2 = \sqrt{\frac{m^2 t_2}{T}};$$

on the same page, line 21 from the top, N_1 should read M_1.

Let us now suppose a case in illustration of these formulæ. Let there be a feeder, A B, which splits into two branches B C



and B D. The data for the two branches being given, it is required to find the thermal current in the feeder—or the number of lamps to which it corresponds. We have given

(for B C)	(for B D)
$\mu_1 = 400$	$\mu_2 = 250$
$M_1 = 60$	$M_2 = 40$
$t_1 = 5$	$t_2 = 6$

We must suppose that N_1 and N_2 have also been independently calculated (by means of equation (4), or certain developments of that equation, which we shall presently consider); but in order that we may not assign for them impossible values, we will find the limits of N_1 and N_2 by means of equations (8) and (10).

N_1 lies between $\left\{ \sqrt{M_1 \mu_1} = 155 \right\}$ and $\left\{ M_1 \sqrt{\frac{T}{t}} = 131 \right\}$

N_2 " " $\left\{ \sqrt{M_1 \mu_1} = 100 \right\}$ and $\left\{ M_2 \sqrt{\frac{T}{t_1}} = 80 \right\}$

Suppose we put $N_1 = 140$ and $N_2 = 90$, assuming, as we have already said, that these particular values have been obtained by an independent method of calculation, then we know that

$$N \text{ lies between } (M_1 + M_2)\sqrt{\frac{T}{t}} \text{ and } (N_1 + N_2).$$

We may, if we like, obtain the exact value of t by means of (20), or, using (21), we can see that $t = 5{\cdot}25$ nearly, say $t = 5{\cdot}2$. We shall now obtain

$$(M_1 + M_2)\sqrt{\frac{T}{t}} = 215, \text{ and } (N_1 + N_2) = 230;$$

so that N lies between 215 and 230.

It will be interesting to find the numerical values of the other limits. We shall find that

$$\sqrt{N_1^2 + N_2^2} = 167, \text{ and } \sqrt{\{(\mu_1 + \mu_2)(M_1 + M_2)\}} = 255.$$

The reason why the three superior values happen to be comparatively near together is that the values of t_1 and t_2 were taken rather near τ_1 and τ_2.

It is evident that as regards the maximum limit of N the formula is applicable to the collation of any number of terms at once, and for the inferior limit all terms having nearly the same values of t can be taken together, and the remaining terms can be taken successively by means of equation (20).

Having arrived at this point we can see that if the lamps upon any given section are classed in any number of divisions, and if for each division we can calculate the values of M and N with any probable degree of accuracy, we shall afterwards be able to collate these divisions and find the limiting values of the thermal current for the whole section. But, further, our knowledge of the method according to which the lamps have been classed in the several divisions will in each case

*Paper read before the Society of Telegraph-Engineers and Electricians.

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suggest a means of arriving, with more or less accuracy, at the value of A in equation (14). We shall thus get still nearer to the most probable value of N for the whole section.

After this we shall have to collate the thermal currents of the various sections with each other, working up towards the machines, but here we shall have to rely almost entirely upon the method of limits. It should, however, be noted that at any point in the process the ratio between the superior and inferior limits of the final thermal current for any given section will be *less* than the (arithmetical) mean value of the ratios between the limiting values of N_1, N_2, &c., from which it is obtained, except in the case when all these ratios are equal. For example, taking the first section—and, therefore, the largest conductor—although the *difference* between the superior and inferior limits of the possible values of N is here at a maximum, yet the *ratio* between these two values cannot in any case be greater than the mean values of the ratios of the values of N_1, N_2, ... for all the other sections.

We have yet another step which it may sometimes be worth while to take. At any point in the process of collating the values for the separate sections we can make a direct calculation of the value of the thermal current for all the lamps which are supplied through that section, by proceeding as though all lamps lying beyond were connected directly to that section, finding the thermal current for the different groups, and collating as before. But although this process may be valuable as a check, especially in the case of some of the larger mains, it will be seen in the sequel that in most cases it involves very long and somewhat complex calculations.

One other point may be mentioned here. We have been obliged always to assume that the current supplied to the lamps connected directly to any given section flowed through its whole length. Virtually we treat the case in which all the lamps are placed at the extreme end of the section to which they are connected. The error thus introduced is of course one of excess. It may be minimised by judiciously placing the sections, and also by increasing their number. It may sometimes be desirable for this and other reasons to make the calculations for a much larger number of sections than we shall probably actually employ.

We now proceed to consider in what way the principles which we have sought to establish may best be applied. The following scheme is an attempt to determine the most probable value of the thermal currents in the distribution of electricity upon a large scale as the problem will usually be presented in practice. We need only describe in detail the method employed to find N. This will involve all the data for M (so far as these quantities are capable of being ascertained).

Now the whole of the lamps supplied from any lighting station may obviously be placed in one of two divisions according to whether their period of burning is (1) regular or (2) irregular.

Among the "regular" lamps we shall include all those whose usage is in any sense periodic, whether or not they are in daily use. This division may again be separated into two main groups,

Group I., containing all lamps which are lit *at dusk* and extinguished either at dawn or at any hour which can be approximately assigned;

Group II., containing lamps which, although in regular use, are not *always* lit at the hour of dusk.

We shall find it necessary later to further subdivide each of these groups, but for the present we may leave them intact. It will be evident that Group I. includes all street lamps, very nearly all those in shops, warehouses, offices, clubs, railway stations, &c., and probably a very considerable proportion of those in private houses. Group II. consists principally of those in places of worship, halls, theatres, and similar public buildings. The "irregular" division contains all remaining lamps (apparently *chiefly* in dwelling houses) for which it is not possible to assign any approximately periodic or constant usage. It is evident that even if in any case the "irregular" lamps form a numerically large class, yet by far the larger share of the total work will be performed by the 1st division. It is therefore worth while to work out the probable thermal current for this division with as much accuracy as possible.

Division I.—"Regular" Lamps.

We have first to decide how we shall take account of the variation in the number of lamps alight due to the time of the day, the day of the week, and the period of the year. Now, we know that the total annual period from sunrise to sunset is the same on all parts of the surface of the earth, except where modified by local physiographical or topographical features. It follows that the (normal) mean annual night is everywhere twelve hours long, and we may take it to last from 6 p.m. to 6 a.m. (local time).

Group I.

It follows that for Group I., in which the lamps are lit at dusk, we shall be able, for the purpose of this particular calculation, to consider the hour of lighting to be 6 p.m. all the year round. This will give us the same number of lamp-hours (whatever may be the hour assigned for their extinction) as if we reckoned from the true hour of sunset day by day. This statement, however, requires one obvious qualification: clearly, if there are any lamps which in winter-time are lit at dusk and are extinguished before 6 p.m., they will be excluded from this reckoning. We shall therefore have to form a sub-group (which we will distinguish as Group Ia.) for these lamps; and, when necessary, we must make a separate calculation for them by a method which will be afterwards dealt with.

Having thus determined the normal hour of lighting for these lamps, we shall have to ascertain the usual hour of extinction in each case from the individual consumers. This ought not to be a matter of much difficulty. In order that we may see clearly the nature and extent of the information required, it may be worth while to sketch out a form of circular which might be issued for this purpose.* Omitting the necessary preamble, we might proceed to ask the following questions:—

(1) What is the total number of lamps required on your premises?

(2) How many of these are lit, as a general rule, at dusk?

(3) At what time (approximately) are they usually extinguished?

(*Specimen answer*) 6 at 8:30 p.m., 4 at 10 p.m., 2 at 11:30 p.m.

(4) If answers (2) and (3) do not apply to each day of the week, please state the exceptions.

(*Specimen answer*) On Saturdays 10 lamps burn until 10:30 p.m., and the other 2 until 12 p.m. On Sundays 6 lamps only burn until about 11:30 p.m.

(5) With regard to those lamps, if any, which you do not usually light at dusk, any approximate information as to their use will be esteemed.

Having obtained this information and summarised it (for each section of the cable separately), we shall be in a position to calculate the probable value of the thermal current. From what has been said before, it will be understood that any lamps burning till dawn are reckoned as being extinguished at 6 a.m.

In the first instance we have equation (4)—

$$N = \sqrt{\left\{ \frac{n_1^2 t_1 + n_2^2 t_2 + \ . \ . \ . \ .}{T} \right\}}$$

It will probably be deemed sufficiently accurate (at least for our present purpose of illustration) if we make the periods t_1, t_2, . . . each equal to one half-hour. The formula then becomes

$$N = \sqrt{\left\{ \frac{n_1^2 + n_2^2 + \ . \ . \ . \ .}{2\,T} \right\}} \quad . \ . \quad (21a)$$

where n_1 is the total number of lamps (in this group) burning during the interval from 6 p.m. to 6:30 p.m., n_2 is the number burning from 6:30 to 7 p.m., and so on. But as it stands at present this formula takes no account of variations due to the day of the week. We will suppose that the group presents a well-defined variation in the numbers both for Saturday and for Sunday. We shall now have to make, in effect, three sub-

* It is obviously desirable that this circular should be issued in the months of December or January.

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divisions of Group I. And although it is true that we shall here count many, or perhaps all, of the lamps over again in each sub-division, yet it will be obvious that this is equivalent to the case in which we have two or more distinct sets of lamps *which are never run contemporaneously.*

We will indicate the values of N in Group I. for week-days by N_1, for Saturdays only by N_1', and for Sundays only by N_1''.

We shall then have for N_1 (five days per week),

$$N_1 = \sqrt{\left\{ \frac{5\,(n_1^2 + n_2^2 + \ldots)}{7 \times 2\,T} \right\}} \quad \ldots \quad (22)$$

But it will generally be more convenient to make the period annual instead of weekly, as we can then readily take account of the six annual holidays, or of any similar variation. Putting $(365{\cdot}25\ T) = Q = 8{,}766$, the number of hours in one year, we shall have

$$N_1 = \sqrt{\left\{ \frac{d_1\,(n_1^2 + n_2^2 + \ldots)}{2\,Q} \right\}} \quad \ldots \quad (23)$$

and, similarly,

$$N_1' = \sqrt{\left\{ \frac{d_1'\,(n_1^2 + n_2^2 + \ldots)}{2\,Q} \right\}} \quad \ldots \quad (24)$$

$$N_1'' = \sqrt{\left\{ \frac{d_1''\,(n_1^2 + n_2^2 + \ldots)}{2\,Q} \right\}} \quad \ldots \quad (25)$$

in which d_1, d_1', and d_1'' represent respectively the number of days *per annum* for which each sub-division is to be counted. The values of n_1, n_2, ... of course will differ in the three formulæ, but it has not been thought necessary to employ any distinguishing mark.

In order to obtain the values of the enumerators it is convenient to prepare a table in which to set out the values of n_1, n_2, ... and their squares. A separate table will of course be required for each sub-division.

The following is given as a specimen. To save space, it is supposed that all the lamps are extinguished by 9 p.m., save some which burn till dawn.

SPECIMEN TABLE.

"Regular" Division—Group I.

(Cable x, Section y) N_1 (5 days per week) $d_1 = 255$, $\mu_1 = 360$.

A.	B.	C.	D.	E.
	p.m.			
1	6:30	40	360	129,600
2	7: 0	60	320	102,400
3	7:30	0	260	67,600
4	8: 0	20	260	67,600
5	8:30	100	240	57,600
6	9: 0	40	140	19,600
...	...	0	100	...
...	...	0	...	...
	a.m.			
24	6: 0	100	100	180,000
		Total		624,400

Column A gives the subscripts of n.

„ B gives the time of expiration of the corresponding half hour.

„ C is obtained from the summary relating to this particular section, prepared from the replies to the circular, and gives the number of lamps *extinguished* at the end of each half-hour.

„ D gives the number of lamps *left burning* during each such period.

„ E gives the squares of the preceding column.

μ_1 is here the number of lamps in the group, not the total number on the section (which we write μ). It is therefore evident that the first number in column D will always be μ_1, and the other numbers are obtained by successively subtracting the numbers in column C. In this case by means of formula (23) we shall obtain $N_1 = 93$.

It may conduce to clearness if we here re-state what is implied by this result. We find, then, that if upon this section 93 lamps burn night and day all the year round, the same amount of energy would be wasted in the conductor as is actually wasted by the 360 lamps which each burn so many hours in the day on 255 days per annum *only.* d_1 was put equal to 255 by omitting Saturdays, Sundays, and six holidays.

The values of N_1' and N_1'' having been found in the same way, we proceed, before collating these three terms, to complete the calculation of the other groups for the same section.

(To be continued.)

THE ELECTRICAL CONDUCTIVITY OF CARBON COMPOUNDS.

Conductivity has been measured by interposing small thicknesses of the solid or liquid to be tested in the circuit of a battery composed of 400 zinc and chromic acid cells. In the case of liquids, it was also determined by observing the rate of change of potential of a metallic ball immersed in the liquid. The results obtained were as follow:—All solid carbon-compounds are non-conductors if measured at some distance below their melting point. All hydro-carbons and their chlorine, bromine, iodine, or cyanogen derivatives, ethers, and ethereal salts are non-conductors when in the liquid state. Water, alcohols, acetone, aldehydes, acids, anhydrides, quinones, phenols, and amines and their derivatives containing negative radicles show unmistakable signs of conductivity. The conductivity decreases with the increase in complexity of the molecule. Conductors, when dissolved in non-conducting media, form conducting solutions. Non-conducting liquids do not become conductors when heated, but the conductivity of conductors is increased by heat.

THE PHILADELPHIA EXHIBITION, 1884.*

(Continued from page 106.)

REPORT OF EXAMINERS.—*Section VI.—Carbons.*

Section VI. had submitted to it for inspection and report the carbons from five exhibitors, viz.:—

The Brush Electric Company, the Wallace Carbon Company, the Boulton Carbon Company, the Buffalo Carbon Company, the Carré carbons, manufactured by Emile Levy, Paris, and exhibited by Messrs. J. W. Queen and Co.

Of these, the Brush, Wallace, and Boulton companies submitted plain and copper-coated carbons, the Buffalo Company a homogeneous carbon, both plain and copper-coated, and, in addition, a carbon with a core of pure graphite inserted in a sheathing of coke and a carbon with a vitrified coating, while Queen and Co. offered only the uncoated Carré carbons. It was determined to have chemical, physical, and mechanical studies made of these carbons, but the study of the physical characters, resistance, duration of burning in the lamp under different conditions of current, &c., was handed over to the Section on Arc Lights, whose chairman, Prof. William A. Anthony, agreed to take this part of the work. The chemical and mechanical study was apportioned out among the members of the section who now present this report, and included determinations of the percentage of carbon, hydrogen, and ash, with a qualitative examination of the chief constituents of the latter in the several plain or uncoated samples the amount of copper on the coated carbons, both absolutely by weight and relatively per unit of length; specific gravity determinations on the uncoated carbons, both with sections of the solid carbons of given length and with the pulverised material; and, lastly, a microscopical study of the structure of the carbon pencils, using for this purpose specially prepared thin cross sections. The aid of micro-photography was also availed of in this latter case for the proper illustration of the results.

1. *Determination of the Percentage Composition of the Uncoated Carbons* (Carbon, hydrogen, and ash).—This was undertaken by Prof. Samuel P. Sadtler, and was made to include five samples, viz., the plain Brush, Wallace, and Boulton carbons, the plain solid Buffalo carbon, and the Carré carbon. The Buffalo carbon with the graphite core was not analysed, as the agent of the company said that the sheathing was made exactly of the same materials and by the same methods as the solid carbon exhibited, while the pure graphite core had a sufficiently well-known composition. The greater part of a single pencil having been reduced to fine powder, the material for analysis was taken from this stock. The determinations were made by the methods of ultimate analysis, using an open

* From the *Journal* of the Franklin Institute.

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TABLE I.

	Brush Carbons.			Wallace Carbons.			Boulton Carbons.			Buffalo Carbons.			Carré Carbons.		
	I.	II.	Aver.	I.	II.	Aver.	I.	II.	Aver.	I.	II.	Aver.	I.	II.	Aver.
Carbon.....	97·61	97·81	97·71	95·92	...	95·92	98·19	98·24	98·21	97·68	...	97·68	95·98	95·84	95·91
Hydrogen	1·32	1·22	1·27	1·15	0·97	1·06	0·72	...	0·72	1·51	1·60	1·55	1·00	0·73	0·86
Ash	0·64	0·61	0·63	2·94	2·80	2·87	0·87	0·88	0·87½	1·09	1·08	1·09	1·91	1·83	1·87
Occluded air or loss.....	0·43	0·36	0·39	...	...	0·15	0·22	...	0·19	...	...	...	1·11	1·60	1·36
Totals	100·00	100·00	100·00	100·01	...	100·00	100·00	99·12	99·92	100·28	...	100·32	100·00	100·00	100·00

tube, three-fourths filled with granular cupric oxide, placing the weighed material in a platinum boat, and conducting over this a slow stream of oxygen. In this way, besides the carbon and hydrogen determinations, the ash could be accurately weighed, and a check established upon the whole. The results were as in Table I.

In looking at these figures, several points of interest at once present themselves. The Brush carbons have the smallest ash of the series. On account of their rather more open and porous structure, there is room for occluded air in this case, as the result shows. The Wallace carbons have the largest amount of ash of the series. The character of this ash will be noted further on by another member of the committee. This carbon is closer in structure than the Brush carbon, being made in an entirely different way, and there is no occluded air to look for. The Boulton carbons, though having a higher percentage of ash than the Brush carbons, have a higher carbon and a lower hydrogen percentage, possibly having been burned at a higher temperature. The Buffalo carbons show a distinctly higher percentage of ash than the Brush or the Boulton carbons. The hydrogen percentage as given is possibly a little too high, as the summing up seems to show. The Carré carbons show a large ash, although considerably less than the Wallace carbons. The porous structure of these hydrocarbons offers, no doubt, a partial explanation for the relatively large percentage of occluded air and loss.

2. *Determination of the Percentage of Ash and Qualitative Examination of same.*—This was undertaken by Dr. Charles B. Dudley, and the examination was made upon a portion of the same pulverised material as that used by Prof. Sadtler in the combustion analyses. The results were as follows :—

The Brush carbons yielded 0·478 per cent. of ash. A qualitative examination showed that the portion insoluble in acids was slight ; that there was a considerable amount of ferric oxide and a trace of magnesia. The Wallace carbons yielded 2·672 per cent. of ash. A qualitative examination showed a large insoluble residue and a large amount of the oxides of copper and iron. The Boulton carbons yielded 0·892 per cent. of ash. A qualitative examination showed a small insoluble residue only, a large amount of ferric oxide and a trace of magnesia. The Buffalo carbons yielded 1·104 per cent. of ash. A qualitative examination showed a small insoluble residue, much ferric oxide, and a trace of magnesia. The Carré carbons yielded 2·086 per cent. of ash. A qualitative examination showed considerable insoluble residue, much ferric oxide, and considerable lime.

It will be seen that these ash determinations correspond quite generally, in some cases with great exactness, to those gotten in connection with the combustion analyses of the carbons.

Sample.	Length of coating.	Copper on length of 4 c. m.	Copper per centimetre.	Total copper (not including that on end).
	Millimetres.	Grammes.	Grammes.	Grammes.
Brush carbon ...	281	·1621	·040525	1·1388
Wallace carbon..	297	·0180	·0045	0·1337
Boulton carbon..	272	·1853	·046325	1·2600
Buffalo solid carbon	262	·1010	·02525	0·6616
Buffalo core carbon	253	·1525	·038125	0·9645

3. *Determination of Copper on the Copper-coated Carbons.*—These were made by Prof. Wm. H. Greene, upon the samples of the Brush Company, the Wallace Company, the Boulton Company, and both the homogeneous and graphite-core carbon of the Buffalo Company. No copper-coated sample of the Carré carbon was exhibited. The results are given in tabular form in Table I.

4. *Specific Gravity Determinations.*—These are undertaken by A. E. Outerbridge, Jr., and were made upon the uncoated carbons of the Brush, Wallace and Boulton Companies, the French Carré carbon, and the plain, the graphite-core, and a glazed carbon of the Buffalo Company. A superficial examination of these carbons showed that some of them were much more porous and of coarser grain than others ; it was thought advisable, therefore, to make two different determinations of each sample, one for the purpose of ascertaining the specific gravity of the pencil, and the other the specific gravity of the material of which the pencil is composed. For the first method the samples were all cut to the same length, viz., 5 centimetres. These were first heated to a moderate temperature to expel the moisture absorbed in their pores and further dried in a desiccator ; when quite cool they were weighed upon a delicate analytical balance, sensitive to less than one-tenth of a milligram. The pencil was then coated with shellac varnish to prevent the absorption of water when immersed. When the thin coating of shellac was hard the sample was suspended from the beam by a filament of silk and reweighed ; this was the weight used in the specific gravity determinations. The sample was then immersed in a beaker glass of distilled water at 60° F. and weighed. The specific gravity of the pencil was then determined by the usual calculation. In order to determine the specific gravity of the material of which the pencils are composed, it was first ground to a fine powder in a steel mortar, put through a "No. 80" sieve, warmed to expel moisture, dried in the desiccator and weighed. The weight taken in this case was usually two grammes. The specific gravity bottle which was used in these determinations was filled each time with distilled water at, or very near, 60° F., and weighed ; the water was then poured out, the powder put in, the bottle refilled with water (care being taken that no air-bubbles remained) and reweighed ; from which data the specific gravity of the sample was determined.

(To be continued.)

ON THE ELECTRIC RESISTANCE OF A NEW ALLOY NAMED PLATINOID.*

BY J. T. BOTTOMLEY, M.A., F.R.S.E.

In the course of a series of experiments on the electric resistance of various metals and alloys, and in particular on the variation of the electric resistance of these metals and alloys with temperature, the author has examined a new alloy (called by the inventor "platinoid"), which has turned out to have important properties. This alloy is the invention of Mr. F. W. Martino, of Sheffield, who kindly supplied specimens of the metal, and wires specially drawn down to the finer gauges for experiments. Platinoid is practically German silver with the addition of a small percentage (1 or 2 per cent.) of metallic tungsten. The tungsten is added in the form of phosphide of tungsten, a considerable percentage of which is in the first place fused with a portion of the copper. The nickel is then added, and then the zinc and the remainder of the copper. The mixture requires to be re-fused more than once, and during the process the phosphorus and a considerable portion of the tungsten originally added are removed as scoriæ. In the end there is obtained a beautiful white alloy, which is platinoid. When polished the alloy is scarcely distinguishable in appearance from silver. To test the quality claimed for it as to being untarnishable, the author has been keeping ornamental specimens lying exposed to the ordinary town atmosphere ; and has satisfied himself that the alloy has a very remarkable power of resisting the tarnishing influence of the air of a large town. It is, however, the electric resistance of platinoid that has chiefly interested the author. German silver wire has proved of great use in the construction of galvanometer coils and resistance coils, on account of two important properties, viz., its very high resistance and the smallness of the variation of its resistance with change of temperature. Both those properties are possessed in a still higher degree by platinoid alloy. The resistance of German silver differs considerably in different specimens. It is commonly stated to be $21{\cdot}17 \times 10^{-6}$ B.A. ohms between opposite faces of a centimetre cube at 0° C. ;† or, reducing to legal ohms, $20{\cdot}935 \times 10^{-6}$ legal ohms between the opposite faces of a centimetre cube. Table A on next page shows the resistance of a number of specimens of platinoid wire :

It appears from these results that the specific resistance of platinoid is about *one and a half* times that of German silver. The experiments on the variation of resistance of platinoid with temperature were carried on in the following way :—The specimen of platinoid to be tested was wound on a wooden bobbin, on the surface of which a screw had been cut, and the spires of the helix were kept separate by lying between the threads of the screw. This coil was immersed in a bath of oil, and was connected in series with a known wire of German silver, the temperature of which was kept constant, and with a single Daniell's cell. The differences of potential between the two ends of the platinoid wire and the two ends of the German silver wire were determined by applying the electrodes of a high-resistance

* Paper read at the Royal Society, May 7th ; note added May 12th.

† Given by Prof. Fleeming Jenkin, F.R.S., as expressing the results of Matthiessen's experiments.

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galvanometer. The ratio of the differences of potential is the same as the ratio of the resistances of the two wires.

TABLE A.

Specifying Number.	Diameter in decimals of centimetre.	Cross Sections.	Resist. legal ohms per metre.	Resist. between opposite faces of centimetre cube legal ohms.
16	·1610	·0204300	·181	$36·98 \times 10^{-6}$
17	·1430	·0160200	·202	32·36
18	·1230	·0119400	·288	34·38
19	·1110	·0096770	·353	34·16
20	·0865	·0058760	·555	32·61
A	·0595	·0027180	1·250	$34·76 \times 10^{-6}$
B	·0495	·0019240	1·707	32·85
28	·0402	·0012690	2·605	33·06
29	·0340	·0009070	3·412	30·94
32	·0290	·0006605	4·371	28·87
36	·0220	·0003801	8·219	31·24

In the following table is shown the ratio of the resistances of a specimen of platinoid wire at different temperatures to its resistance at zero. The wire used was the same as that specified as No. 20 in the table of resistances. The length of the wire experimented on was about four-fifths of a metre. The only trouble in the experiment was the keeping the oil-bath, which was filled with linseed oil, thoroughly stirred, and of uniform temperature throughout.

Temperature.	*Resistance.
0°	1·0
10	1·0024
20	1·0044
30	1·0075
40	1·0066
50	1·0097
60	1·0126
70	1·0134
80	1·0166
90	1·0188
100	1·0209

* The Resistance at 0° C. being = 1.

This gives for the average percentage variation of resistance per 1° C., between the temperatures 0° C. and 100° C., the number 0·02087. A second wire tested very carefully in a similar way gave for this average percentage variation between 0° and 100°, 0·022 per degree, with a steadily increasing rate of variation from the beginning. To compare this increase in resistance due to increase of temperature with that observed in other metals and alloys, we find that the percentage increase of resistance for 1° C. at 20° C. for copper is 0·388, platinum-silver alloy 0·031, gold silver alloy 0·065, and for German silver 0·044. These numbers were obtained by Matthiessen in the course of his experiments for finding a suitable metal or alloy for the purpose of constructing the British Association standards of electric resistance. It appears that the variation of resistance of platinoid with temperature is very much smaller than the smallest observed for any of the metals and alloys then examined. The modulus of rigidity, the Young's modulus (or modulus for elastic longitudinal extension), and the breaking weight for platinoid wire were also determined. The wire used was a portion of that marked A in the foregoing table. This wire is a little larger than No. 24 of the Board of Trade standard wire gauge, and has a diameter of 0·0595cm. The rigidity modulus was found to be $4751·8 \times 10^6$ grammes weight per square centimetre. The Young's modulus is $1222·4 \times 10^6$ grammes weight per square centimetre. The breaking weight is about $6·029 \times 10^6$ grammes weight per square centimetre. The specific gravity of platinoid wire has also been found by the author to be 8·78 compared with water at 20° C. Platinoid when drawn hard is softened, like copper, by heating and sudden cooling.

COMPANIES' MEETINGS.

The West Coast of America Telegraph Company (Limited).

The eighth ordinary general meeting of the shareholders of this Company was held on Wednesday, the 24th inst., at the Cannon-street Hotel, under the presidency of Mr. Robinson Kendal.

The SECRETARY (Mr. Fred L. Robinson) read the notice convening the meeting, together with the minutes of the previous meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said: If I were a tractable man, or if I were inclined to follow my doctor's peremptory advice, I should not have been here, but should have been inhaling the deep sea breezes. I have now the pleasure, gentlemen, to move the adoption of the balance-sheet and the report, which show that the gross revenue for the year ending the 31st December last amounted to the sum of £52,011. 10s. 7d., leaving a net balance, after paying debenture interest and all other charges, of £14,523. 15s. 6d., a result which, as the report says, is as satisfactory, all things considered, as could have been looked for, and which has enabled the Directors to commence the regular payment of dividends to the shareholders, and to place the Company, by the creation of the reserve fund, in a much stronger and more healthy financial condition. The report enters so fully into the position of the Company, and so clearly explains everything, that there is little left for me to do at this moment beyond recapitulating what is therein said and what has been read, I suppose, by every shareholder. Up to this time dividends on the ordinary shares have been paid so soon as the finances of the Company admitted of their payment, but the Board think the time has now come to equalise the dividends so far as practicable, and to make them payable half yearly. As you will see by the balance-sheet the sum of £18,000 altogether was paid in dividends last year on the ordinary shares, and a sum of £10,000 was placed to reserve, leaving a balance of £3,349. 1s. 3d. Out of this balance the Board recommend that a final dividend be declared of two shillings per share, with a further interim dividend, out of the net income for the current half year, of two shillings per share, making a dividend of four shillings per share, or a total sum of £6,000. This, I take it, though not so satisfactory as we could wish or desire, is yet far from unsatisfactory considering the drawbacks and difficulties we have had to struggle against in the shape of a deplorable and disastrous war and a necessarily consequent paralysed state of industry and commerce. Our advices from the "West" Coast say that trade is now at its worst, that it cannot well be worse, and that any change at all must be for the better. Now I am not disposed to prophecy or to indulge in predictions as to the future of trade upon the coast or as to the future of our business, but I may point out that, notwithstanding the severe depression in trade, and the universal complaint of the badness of the times, we, as a Company, have nothing to complain of so far this year, but we have something to hope for in the not impossible event of the restoration of peace and the revival of trade over the entire coast. Our receipts so far have not fallen off more than some £900, whilst our expenditure we know has decreased, owing to our cables having been kept in the highest state of efficiency, and owing to the services of our repairing steamer not having been required for even a trifling repair since the beginning of the year. Should peace be restored, and should trade revive—and the newspapers will have informed you of the encouraging hopes in this regard recently to hand—we ought to be the first to benefit by the changed condition of things, for we must not forget, whether trade be good or bad, that we are the possessors of a splendid cable system in as good order and as perfect a condition as it was when it was laid down, extending for some 1,700 miles down the great coasts of Peru and Chili, where many Englishmen before now have realised large fortunes, and where trade and commerce have been in times not long past as active and as profitable as in any part of the world. The Company has had reverses and difficulties of no ordinary character to overcome and to pull through; but these are, I am hopeful enough to believe, all over, and the Company is, it may now be said, moored in comparatively smooth water. Four years since the Company owed to creditors some £26,000, with its cables cut and its trade destroyed, and with little or no hope of seeing how that £26,000 was to be provided for, or its payment postponed. It was provided for, however, and paid off, and not only has this amount been paid off, but we have since that time paid in debenture interest a sum of £48,000, with a further sum, including the amount we propose to pay to-day, of £24,000 interest upon the ordinary shares; whilst beyond this we have placed £10,000 to a reserve account, and, perhaps what is better than even all this, we have to-day at our bankers a further hard cash balance of some £14,000. I beg leave to move the adoption of the balance-sheet and report.

Mr. THOS. FIELDEN CAMPBELL seconded the motion.

The CHAIRMAN, in answer to a shareholder, said that they proposed paying a dividend every half year for the future. He hoped when they met next they should be able to state positively that peace had been declared on the coast of Chili and Peru, and that there was some hope of that trade reviving which for a long time had brought so much profit to English traders in that part of the world.

The motion was agreed to.

Subsequently the retiring Directors, Mr. Thos. F. Campbell and Mr. W. E. M'Andrew, were re-elected to their seats at the Board.

Mr. J. Weise, of Messrs. Turquand, Youngs and Co., was also reappointed auditor, a vote of thanks to Mr. Kendal for presiding terminating the proceedings.

United Telephone Company (Limited).

The annual general meeting of the shareholders in this Company was held at the Cannon-street Hotel on the 25th inst., under the presidency of Mr. James Brand.

The SECRETARY (Mr. Blaikie) read the notice convening the meeting, and

The CHAIRMAN said: Gentlemen, I hope you will agree with me that the report shows a satisfactory result, and that our five years of very hard and anxious labour and earnest attention to your affairs have now been attended with a fair amount of success. This last year you will notice we spent on capital account on the London system about £20,000. Our revenue has increased by about £10,000, and our working expenses by something like £600. We have written off the large sum of over £13,800 for depreciation of wires and plant in London and instruments in use in the provinces and all over Great Britain and Ireland. This makes in all between £48,000 and £49,000. We are still, I am sorry to say, without exact data which would enable us to form an entire conclusion as to the right figures at which we are to estimate this depreciation, but we have tried to provide more than is necessary

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rather than less for this purpose. In addition to this maintenance and renewal of wires, which is going on more or less every day—for we are in the course of our business maintaining and renewing wires every day, which is provided for out of the revenue—there is this sum written off for depreciation. Besides this the reserve fund is over £65,000, and this we propose to increase by £10,000, so that will make over £76,000 to the reserve account. Therefore, what with the maintenance and renewal every day, the amount we write off for depreciation, and the amount we write off for reserve, I think, as far as our plant and system in London are concerned, we have sufficiently provided for eventualities. We are somewhat disappointed—and perhaps some of you will be, too—that our progress in London and the suburbs has not been greater. The increase we show is, however, a net increase, and covers the withdrawals, and those withdrawals during the past year have been rather frequent, the majority, I am sorry to say, being owing to the hard times through which we have been passing. I have an analysis of the number of withdrawals, and they are about 300, and if any of you would like to know the exact causes of the withdrawals I shall be glad to tell you. I am glad to say that not a very great proportion has arisen from dissatisfaction, but most of them are from people who have been unfortunate in business, while some have been from people removing their counting houses and not requiring the thing any longer. I may also mention, to account for the reason why our progress has not gone on by leaps and bounds, as was thought would be the case, our business for some months last year was checked by the offer of another company to connect exchange subscribers at lower rates. We are also unable as yet to avail ourselves of the full benefit of the extension of the radius and the liberal terms granted by the Postmaster-General. Before we can commence and fully take advantage of the good things obtained for us in Parliament from the Postmaster-General, we have to do a great deal of work which is for the time unseen, and the value of which cannot be estimated till everything is completed and the result is shown by further subscribers. We have to construct long trunk lines, to canvass very great districts, obtain way-leaves, and do similar very arduous work. This is all now in full progress; but we cannot show you what the result is until it is quite completed, and all those districts are connected with our central exchange. To give you some idea of what has been done I may tell you that we have erected an exchange at Brighton, which works admirably. To-day or to-morrow Clapham and Kilburn will have call rooms attached to our central system. South Kensington was opened the other day. Our eastern exchanges accommodate the whole of the dock system. The telegraph department of the General Post Office has been connected with our central exchange, and in a few days subscribers will be able to speak their messages direct from their offices to the central telegraph room, which will save much time and trouble, and they will be also able to receive any messages sent to them in the same manner. We have also an exchange at the Inventions Exhibition, and we have thirty-four exchange subscribers. We are pushing forth new routes from the city to Chiswick, Kew, Battersea, and Brentford. The wire is run to Sydenham, and will be connected in a few days. I think that will show you that at any rate we are using every endeavour in our power to push forward your business as rapidly as possible. I do not think I need say more about our relations with the Post Office than I have said in the report; I have every reason to hope that they will continue such as to facilitate the extension of your business. With regard to litigation, what we have had hitherto has been forced upon us. We have, I am glad to say, proved to be in the right in every case, and in future the best thing I can say is that we hope to have as little litigation as possible, and much less than in the past. When we last met we were involved in competition with the Globe Company. We felt that though the legal question between us would in the end be decided in our favour, yet this favourable decision must be a matter of time, and in the meantime they were giving us a great deal of trouble in many ways, though we knew that the business they were conducting was not at a profit. Therefore, when they approached us with an offer to sell their stock of instruments, plant, and way-leaves, and, in fact, their whole undertaking, including the patents on which they relied, we thought it was in your interest that we should buy them up; and we think, on the whole, that we did wisely. I do not propose to say more on that subject unless anyone asks any questions. As to our Bill in Parliament, we had promoted a Bill in Parliament for the regulation of overhead wires, and putting the overhead wires under some sort of authority, which we could appeal to in case of dispute between ourselves and any of the authorities or private persons who objected to grant us facilities. We promoted this Bill to a certain extent, and then we found that the Government would not allow us to bring in a Bill on our own account, and they promised to legislate on the subject. The whole matter has been submitted to the House of Commons, and has been thoroughly threshed out, and a Select Committee has come to certain conclusions, which I suppose, by and by, will more or less become law. In the meantime I think a good deal of the public feeling which had been created against overhead wires is subsiding, so many people having found—and finding this from daily use—what a very valuable adjunct, both to public business and commerce and their private comfort in their houses, the telephone has become. Every one who becomes a subscriber and uses the telephone is most anxious to help us in way-leaves, and in this matter we are going on as well as this very difficult question will allow us. We have dropped our own Bill, and are relying on the recommendations of the Committee of the House of Commons; and we expect we shall at any rate know to whom to apply in case of any trouble in pursuing our business. The only matter I have now to speak of is in paragraph 9, and I will read that:—"The formation of a separate company for the metropolitan district having been suggested to the Board, the notice of the meeting has been framed so as to confer the necessary powers upon them, if they should consider it desirable, to proceed with the matter upon such terms and conditions as they feel they could properly submit to the shareholders at the special meeting which it would be necessary to call for that purpose." The words in the paragraph I think will do away with any apprehension that was aroused in certain quarters. I had a few letters myself on the subject about the issue of proxies for our meeting. I can assure you on my behalf that that issue was entirely a clerical error, and we had no wish or intention of pledging the shareholders to any course at all. In a matter so vital to all of us we should not think of entering into negotiations for the sale of our London system without letting you into our full confidence. If there is any misapprehenion as to these proxies I will take the blame on myself, and it will not be done again. As regards this Company, the way this matter came about was this. It has been thought by ourselves sometimes and by some of our shareholders that we do not develop as quickly as we might [hear, hear]. Well, I do not object to that "Hear, hear," because I very often think so myself, but I have been at this work since the very beginning of the whole business. I happened to be the first man almost in communication with Prof. Bell as to the sale of the Bell patents, which were the beginning of our business, and I have passed through it as well as I can with the assistance of the other members of the Board. I have, therefore, seen the enormous difficulties that we have had to surmount. It is a new thing, and we have to be very particular about treading on anyone's toes; the railways cannot give us trunk lines, the Post Office has interfered with us, and so forth. The thing has been full of difficulties, and though I am inclined to think that we do not go on fast enough (and I hope we shall go on faster), yet I know the enormous difficulties that we have had to contend with, and which will have to be contended with by any society who wishes to go on faster. Having these feelings, we listened to some of the suggestions made for the sake of dividing our business. We thought that our patents, the large interest we have now in shares of subsiduary companies, and the looking after infringers of our patents, might be kept under the head of the United Telephone Company, and that we might place the business in London and the suburbs under an entirely new organisation, assisted by our staff and so forth. Certain terms were proposed, and we thought they did not seem unreasonable, and we went up to a certain point in the negotiations. Certain gentlemen had promised to join the Board, and very good men they were, but when we came to discuss the matter with our solicitors, we found, putting aside the question of price, that we should be confronted under certain paragraphs in our Articles of Association, and our agreements with our subsiduary companies, with a state of things that might and probably would land us in a sea of legal difficulties, which it would be very difficult to foresee the end of. We thought, therefore, that on the whole we were not ripe to bring before you a scheme to-day which we could entirely recommend to your approval. We were also guided somewhat in this decision by certain words used to me and my colleagues, and letters I received asking us to bear in mind, now that we had overcome so many difficulties both with the public and the authorities of the Post Office, that we were landed, as was shown by our report, in a position of considerable comparative comfort and prosperity, and that now that the great difficulties had been overcome in the initiation of the enterprise, and had been overcome successfully, if any good was to be got out of a new organisation and business, it should be given to the Company. That view always appealed to us very much, and at any rate, as we learned when initiated into Masonry, we were taught caution; and we thought that before approaching you with any definite proposal we should at least realise to ourselves exactly what difficulties and responsibilities we were going to incur, and possibly search out some scheme which, while organising your business in another way, would enable us perhaps to realise those hopes which are entertained by many of you and ourselves, and retain that profit which we should necessarily have to part with in selling this part of the undertaking to any other company away from ourselves. I do not know that we should say any more on that subject to-day. I do not know that we have made up our minds that it would be wise to sell this part of our business to a separate organisation, but if we pursue the matter further we shall summon a special meeting and tell you all about it. He concluded by formally moving the adoption of the report and accounts, and the declaration of a dividend of 7s. 6d. per fully-paid £5 share (part-paid shares receiving in proportion) for the second half year, ended 30th April, 1885, making a total dividend of 10 per cent. for the year.

The DEPUTY-CHAIRMAN (Mr. James S. Forbes) seconded the motion.

Mr. LEYLAND said he had no doubt that the Directors had good reasons for asking for the powers which they did, but the notice had come very unexpectedly on the shareholders, and had created a good deal of excitement; but he thought that this matter had been pretty well explained in the report, which, however, had come out rather late in the day. He considered that the report and accounts ought to be in the hands of the shareholders at least a week before they came to consider them. He was very glad to hear what the Chairman said as to the development of the business. He did not think it was good policy to spur a willing horse, but seeing that they had only six years more to run with their patents, when they would be open to the world, he considered that their true policy was to develop their business in that period to the utmost. He observed an asset of £654,000 in shares of subsidiary companies, and obviously that was at the very backbone of the success of the Company. They seemed to derive in royalties very much the same amount as from the balance of revenue account; and he presumed that the great bulk of the royalties came from the subsidiary companies. He trusted that the Directors looked after the power they had of appointing Directors on the Boards of these companies. As to the negotiations which had gone on for the sale of a portion of their business, he thought it would be better in all respects for them to keep it in their own hands, and, if necessary, make some re-arrangement of their organisation, so as to meet their requirements. Looking over the Articles of Association, he found that

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the Directors, after a dividend of 10 per cent. had been paid, were entitled to a share of the surplus profits beyond. He did not at all object to the principle of paying by results, but he wished to know whether this deduction had been included in the accounts.

THE CHAIRMAN: No.

Mr. E. H. GALSWORTHY said that he had been astonished at receiving a proxy paper, but he thought they might be satisfied with the explanation given by the Chairman of this matter. He thought, with the previous speaker, that the accounts should be in the hands of the shareholders seven days before the meeting; and he would be glad to see the accounts made up to June and December, instead of April and October. On the face of the report he did not think it was a bad one. He wished to know what principle they had adopted in writing off £13,820 for depreciation. He quite approved of carrying a certain amount to the reserve fund, for in such a Company they ought to have a good reserve fund. He wished to know whether the 300 withdrawals were included in the 3,820 subscribers.

The CHAIRMAN replied that 300 was the net number.

Mr. GALSWORTHY hoped, if necessary, they would introduce another Bill to settle the question of overhead wires, if the matter was not dealt with by the Government. With regard to the idea of a district company they must feel very much obliged to the Chairman for what he had told them. He had been going to suggest that if the idea was to be pursued the Directors would take no step whatever till they had given full opportunity to the shareholders to consider the whole scheme and the terms upon which they suggested parting with the business. The difficulty of managing the Company was considerable, and he was not sure that the Directors would not have enough to do with looking after that part of the business to which the Chairman had alluded. He considered that if a new company were formed the shareholders in this Company should have the option of taking the shares. He thought it would be well if in the future the Directors gave the shareholders in the report some idea as to how the subsidiary companies were going on, when they would be able to form some idea of the value of that asset in the balance-sheet.

Mr. F. J. BLADON held that it was only in fostering subsidiary companies that they could realise their goodwill, but at the same time he thought the Board was thoroughly capable of developing the metropolitan business in a manner most to the advantage of the Company. He thought they should give up all idea of parting with this branch of the business.

Mr. SICHEL said that the results set out in the report showed the zeal and ability with which the affairs of the Company had been conducted by the Directors. With regard to issuing the capital of a new company (if it were brought out) to the shareholders of the present Company, there were several difficulties in the way of doing so by the rules of the Stock Exchange. The Stock Exchange would not consider such a subscription an open one, and would not grant an official quotation. Apart from that, however, he knew that there was a very general opinion that the sale of the backbone of the undertaking, although it might be a wise proceeding for the moment, could not be so ultimately, and must cause loss in the future. He threw out the suggestion whether the addition of one or two members to the Board, to take the special management of new subscriptions, would not give them all they could expect from a second Board and a new organisation. The business could be enormously developed at the West End, where there were immense blocks of properties, to the occupants of which the telephone would be of essential use, and they might be induced to become subscribers on the Company giving them some reduction. He did not know whether these people might not be canvassed, the work being paid for by commission.

The CHAIRMAN: I think I may begin by saying that, after the unanimous expression of feeling by the meeting—which, as I said, is a good deal concurred in by your Board—we will drop the idea of the metropolitan company. But we have had it in our minds for some time to have some division of the business of the Company inside, which we hope will, before we meet next year, produce better results than are before you to-day. I am very much obliged to Mr. Sichel for his really very valuable suggestions, and I do not want to take away from the value of them by saying that they have been considered very much by ourselves. The difficulties, however, have been so great that we have not seen our way to carry out what we require to the fullest extent, but by this subdivision of our business we hope this very matter will be carried out. Both Mr. Leyland and Mr. Galsworthy suggest that the Directors should publish the accounts for a longer time before the meeting. To that we fully agree, and we will take care that this is done in the future, and that they shall be published at least seven days before the meeting. As to the patents having only six years to run, we know that they will expire, but still we hope that we shall have so fully occupied the ground by that time that the dropping of the patents will not be so serious a matter. No doubt a great deal of our prosperity now (and it will be more so in the future) will depend on the way in which the subsidiary companies are managed, and we will adopt Mr. Galsworthy's suggestion and give you some information in our next report as to our position with them and the position of those companies themselves. Of course, when the royalties on our patents are over, that in a way will make our share in the profits of the subsidiary companies more valuable, because the new companies will then be free from the royalties. As to making up the accounts to June and December, I do not suppose the meeting care much about making the change now, and I think that is a matter that may be left for the present. With regard to the principle on which we charge depreciation, we arrive at that in a sort of rough and ready way. We take a varying percentage—about 15 to 20 per cent. on the wires, and 10 per cent. on the instruments. We have got a scale which we should be glad to show you if you like afterwards. The Post Office themselves have no trustworthy data in this matter. As to promoting another Bill in Parliament, we do not exactly know what the Government is going to do. We were very gratified by the decision come to by the Select Committee, and we hope that the Government will carry it out. If they do not, we shall of course have to think what we shall do. As Mr. Sichel pointed out, we should have had no difficulty in bringing this new company out if we could have offered the whole of the shares to our shareholders, and they had taken them up; but then we should not have got a quotation.

Mr. BLADON: You could have done it by an increase of capital.

The CHAIRMAN: Well, we have dropped the idea now. As to the Directors' remuneration, that is an important point [laughter]. All those present who are original shareholders will, I am perfectly certain, agree with me that your Board have earned honestly this extra remuneration, to which we are legally entitled. We have never sought to increase your dividend, of course with the view of making our percentage available or anything of the kind. This year we pay you 10 per cent., and we carry over a large sum more than last year. To tell you the truth we do think we are entitled to this, but we would prefer to leave the matter in the hands of the shareholders.

The DEPUTY CHAIRMAN, in reply to a question, said that, after paying the 10 per cent. dividend there remained to the credit of profit and loss £17,848, which included £5,000 odd brought from the previous year, when they did not pay 10 per cent. dividend. Therefore that £5,000 odd could not form a part of the sum on which the Board were entitled under the Articles of Association to take their percentage. What they were entitled to take upon was £12,787, and 20 per cent. upon that was £2,557. They would see this set out in clause 58 of the Articles of Association, which he read.

A resolution was passed, on the motion of Mr. LEYLAND, requesting the Directors to charge the percentage to which they were entitled,

Mr. GALSWORTHY, while agreeing to the proposal, observing that he did not think it should be taken as a precedent for the future, because the profits might become so very large, and to take 20 per cent. on the surplus over a 10 per cent. dividend would be unfair to the shareholders. He had been informed that there had been a great many transactions in the purchase and sale of shares by Directors of the Company. If that had really been so, he hoped the practice would cease.

Mr. BATTEN was re-elected to his seat at the Board, and the auditors, Messrs. Quilter, Ball, and Co., and Messrs. Price, Waterhouse, and Co., were also re-elected.

The proceedings terminated with a vote of thanks to the Chairman and Directors.

Business Notice.—The Pilsen Electric Light Company have removed their factory and offices to Edward-street, Hampstead-road, N.W.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JUNE 24.		BUSINESS DONE WEEK ENDING JUNE 24. Highest.		Lowest.
Anglo-American	27½,	28½	28		27⅞
Do. Preferred	47½,	48½	48¼		47½
Do. Deferred	7⅞,	8½	8		—
Brazilian Submarine	11⅛,	11⅜	11⅜		11⅛
Cuba	11⅞,	12½	—		—
Do. Preference	18,	19	—		—
Direct Spanish	1½,	2	—		—
Do. Preference	11½,	12½	12		—
Direct United States Cable	8½,	9	8 15-16		8⅞
Eastern Telegraph	11⅝,	11⅞	11⅞		11⅝
Do. 6 per Cent. Preference	13½,	14	13 11-16		—
Do. 5 per Cent. Debentures, 1899	106,	109	107½		106½
Eastern Extension	12⅝,	12¾	12¾		12 11-16
German Union	9½,	9¾	9 9-16		—
Globe Telegraph and Trust	6¼,	7⅛	7⅛		6⅞
Do. Preference	12¾,	13½	13		12¾
Great Northern	14½,	14¾	14 5-16		—
Indo-European	30½,	31½	—		—
Reuter's	7½,	8	7⅞		—
Submarine	180,	190	186		—
West India and Panama	¾,	1	⅞		13-16
Do. 1st Preference	8,	8½	8¾		8
Western Brazilian	6½,	6⅝	6¼		6½
Western Union 7 per Cent. 1st Mortgage	117,	122	—		—
Do. 6 per Cent. Sterling Bonds	100,	103	—		—

TELEPHONES.

Consolid. Telephone and Maintenance	⅛,	¼	⅛		—
Oriental	⅛,	⅜	—		—
United Telephone	12,	12½	12¾		12

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	1⅝		—
Do. (fully paid)	3,	3½	3⅝		3
Hammond Light (£3 15s. paid)	½,	⅝	3-16		¼
Swan	¼,	½	—		—
Maxim-Weston	⅛,	¼	—		—

MISCELLANEOUS.

Telegraph Construction	35½,	36½	36½		36
India Rubber, Gutta Percha, and Telegraph Works	24½,	25½	25⅜		24¾

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NOTES.

PROGRESS IN AMERICA.—The city Council of Detroit decline to advertise for proposals to light the city with gas.

TRANSMISSION OF POWER.—It is said that Sr. A. Bertelli, of Brescia, has invented a new method for the transmission of power.

THE CHOLERA IN SPAIN.—A telegram from Madrid, dated Wednesday last, announces that all the telegraph clerks are ill of cholera.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 26th June amounted to £2,962.

THE ELECTRIC LIGHT AT PEKIN.—The Italian Minister at Pekin recently gave a ball, when the Embassy was lighted by a large number of incandescent lamps.

THE TELEGRAPH TO MERV.—A telegram from St. Petersburg, dated June 30th, announces the opening of telegraph offices at Karibent, Rukhnabad and Merv.

THE AUSTRALIAN COPPER TRADE.—During the past month the shipments of copper from the Australian ports were:—300 tons of copper ingots, and 300 tons of copper ore.

CHURCHES STRUCK BY LIGHTNING.—According to *Il Giorno* the parish church of Collebeato, near Brescia, and the Church of Santa Veneranda, in Mortara, have been seriously damaged by lightning.

NOTICE OF REPAIR.—The Eastern Telegraph Company announce the re-establishment of communication *vid* Suez with India, China, and the Far East by the repair of their Aden-Bombay cables.

CUT THE WIRE.—At the trial of Marchandon it was stated that before the robbery he had cut the electric wire in the apartment in order to prevent the Countess from calling for help should she awake.

THE ELECTRIC LIGHT ON A LEITH PASSENGER STEAMER.—The London and Edinburgh Shipping Company's fine saloon steamer "Iona," 676 tons register, has been fitted up throughout with the electric light.

LIGHTHOUSE ILLUMINANTS.—Sir James Douglas and several members of the Elder Brethren of the Trinity House are conducting a further series of experiments at the experimental lighthouses at the South Foreland.

OBITUARY.—The death is announced in France, on the 21st ult., of M. H. Tresca, membre de l'Institut, and vice-president of the Société Internationale des Electriciens. M. Tresca had arrived at the ripe age of seventy-one.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 26th June were £2,415, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—This company announce that the coupons, due on the 3rd inst., on the debentures of this company, will be paid by Messrs. Barclay, Bevan, and Co. The coupons must be left three clear days for examination.

THE ELECTRIC LIGHT FOR RESERVOIRS.—On the occasion of the re-opening of the Nottingham Park-row Reservoir recently the reservoir was lighted by five 2,000 candle-power arc lamps by Oppenheim Bros., of London, under the superintendence of Messrs. Bowman and Smith.

TELEGRAPH STATISTICS.—A Florentine publisher, who has been able to find complete postal statistics of the world down to 1883, has just issued them in book form. In that year there were in Europe 41,500 telegraph offices, and the number of telegrams transmitted amounted 117,000,000.

FREEMASONRY.—On Saturday, the 27th ult., the "Electric" Lodge held their second meeting, when Mr. Crookes was passed, and Messrs. J. E. Spagnoletti and W. H. Denny were initiated. Subsequently the members dined together, the usual loyal and masonic toasts being duly honoured.

BATTERY WITH TWO LIQUIDS.—M. Dupre has succeeded in suppressing the nitrous vapours of the Bunsen battery by using a depolarising liquid, consisting of nitric acid in which 75 grs. potassium dichromate have been dissolved per litre. In contact with the zinc he employs either acidulated water or potassium disulphate.

THE CANADIAN TELEGRAPHS.—The new telegraph line from Dunmore to MacLeod, in the Canadian North-West, is being worked. There are offices at MacLeod barracks and Lethbridge, and a telegraph line is to be constructed from Calgary to Edmonton, and another from Medicine Hat to some part of the international boundary.

THE CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of June was 3,715, estimated to produce £3,000, against 3,531 messages, producing £3,168, in the corresponding month of last year. The traffic receipts for the month of March, estimated at £3,500, realised £3,510.

SOCIAL.—The officers of the old telegraph companies held their annual dinner at the Salisbury Hotel, London, on Wednesday, the 24th June. Sir Charles Bright occupied the chair, and amongst the officers present were Messrs. Spagnoletti, E. Graves, Newman, Boys, Walsh, and Radcliffe. Mr. C. H. B. Patey, of the Post Office Department, was present as a guest.

MESSRS. KRUPP'S WORKS AT ESSEN.—The latest published report of the establishment of Messrs. Krupp, Essen, shows that at Essen alone railway tracks of a total length of 37 miles are laid down, with a rolling stock of 88 locomotives, 893 waggons, 191 trollies, besides 69 horses. There are 40 miles of telegraph wires, 35 telegraph stations, and 55 Morse apparatus.

THE ELECTRIC LIGHT IN MUNICH.—A recent number of the *Archiv für Hygiene* contains a valuable report by Dr. P. Renk, one of the instructors in the hygienic institute at Munich, upon the results of a series of observations made by him in the Royal Theatre at Munich, which has been recently fitted up with a system of electric lighting, including more than 1,400 Edison lamps actuated by six large dynamos.

PUBLIC LIGHTING OF LIEGE.—The Thomson-Houston Electric Co., of Boston, U.S.A., has, through the American Vice-Consul for Liége, made the following liberal proposition for lighting that city, viz., to illuminate gratuitously, for three months, all the streets, boulevards, avenues, &c., and if such lighting give general satisfaction, to give in a tender for the permanent lighting, in competition with the gas companies.

THE TELEPHONE AND FIRES.—On the occasion of a fire which broke out recently on the extensive premises of the British Xylonite Company in High-street, Homerton, the telephone rendered very valuable assistance in summoning additional engines. In regard to the recent outbreak at Whiteley's, we are requested to state that the Brigade were summoned by the Exchange Telegraph Company's fire alarms, the telephone being used to summon Captain Shaw.

THE SUBWAYS OF THE CITY.—During the course of the proceedings in connection with the annual meeting of the

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Municipal Engineers the subways of the Holborn-viaduct and Snow-hill were visited, by permission of Lieut.-Colonel Haywood, the city engineer, and were found to be specially interesting—indeed, these remarkable subways, with their many lines of water pipes, gas pipes, and electric wires, are a portion of subterranean London which deserves to be more widely known and to be extensively imitated.

THE POST OFFICE TELEGRAPHS.—Some remarkable work was done on a quadruplex circuit during the Ascot races between the Central Telegraph Station and Ascot. On Monday, 2,325; Wednesday, 3,007; Thursday, 2,234; and Friday, 2,132 messages were sent, making a total of 9,698. The greater part of the work of each day was confined to three hours. On one day 1,691 messages were dealt with between noon and 3 p.m. In one hour 606 messages were signalled. The messages were of average length. Multiple address and press messages were counted as one message.

THE THUNDERSTORM IN PARIS.—During the recent thunderstorm in Paris the lightning fell at the Sceaux railway station, and set on fire the office of the under station-master, but the flames were soon extinguished. The Church of the Madeline received a violent discharge of electricity, which seems to have made itself felt all round the spot. At the same time, a newsvendor who sells journals in a kiosque was rendered nearly insensible, and a waiter in a coffee-house and a person passing the street were thrown down. The lightning seems to have entered a number of houses, but without causing any fatal or even severe accident.

ELECTRIC LIGHTING OF THE BRUSSELS-SCHAERBEEK STATION.—The arrangements for lighting the sidings at the new Schaerbeek Station, Brussels, are now complete. Eight double arc lamps, on the Gülcher system, which burn 16 hours without renewing the carbons, are mounted on iron trelliswork masts, 35 metres or 115ft. high; and any of them can be thrown in or out of circuit by means of switches in the engine room. The lamps are raised to the tops of the masts by a winch at each, the wire cords being protected by tubes. The dynamo is driven at 400 revolutions a minute by a 25 horse-power engine, provided with expansion gear variable by the governor.

NEW TELEPHONE EXCHANGES.—On June 26th the National Telephone Company opened their new Exchanges in Whitehaven and Workington, and a trunk wire between those towns. Most of the chief firms have become members, and on the opening day the traffic over the trunk wire, which is 8¾ miles long, was incessant, the average number of connections per subscriber at the close of the day amounting to over 5. This system is the nucleus of a general telephonic system for Cumberland. Trunk wires from Workington to Maryport, and from Whitehaven to Cleator Moor and Frizington have been commenced, and an Exchange in Carlisle will be opened about the end of July.

LIGHTING OF THE BRUSSELS HOTEL DE VILLE.—At the meeting of the Brussels Communal Council, on Monday last, the necessary funds were voted for electrically lighting the principal portions of the Hôtel de Ville. There were only two dissentients from the proposition, one of whom called upon the college not to be carried away by *electromania*, observing that the economical side of the electric lighting question had not advanced during the last two years. A supplementary engine is to be put down, which will be capable, if required, of replacing that which now drives the dynamo for lighting the Grand' Place. The specification for the Hotel de Ville installation is already prepared; and the work will shortly be let by public contract.

THE TELEPHONE IN MOROCCO.—For a long time past Señor Rotondo, the Spanish Vice-Consul, has been labouring to establish telephones in Tangier, and has been very desirous of forming an alliance with an English company. A French company from Algiers has set up in opposition to Señor Rotondo, and is establishing telephonic communications everywhere, which is a prelude to other projects. We are glad to see any improvement introduced by anybody whomsoever, but we should like to see the two united, and working harmoniously together. Señor Rotondo is certainly entitled to the best thanks of the inhabitants of Tangier for his untiring efforts to bring the telephones into use there.

RECENT INSTALLATIONS.—Messrs. J. D. F. Andrews and Co. have lately installed sixty-five 20-candle lamps at Messrs. R. and J. Dicks' boot warehouse at 296, High Holborn. This is the principal shop of twelve others in London belonging to these extensive gutta percha boot and shoe manufacturers. The premises consist of work shop, stores, fitting rooms, and sale shop, and the electric light is distributed throughout, being supplied with current from an Andrews A/4 dynamo going at 560 turns per minute, and driven by an eight horse Otto gas engine. The five electroliers in the shop are a new and pretty design, each having five lights with a switch in the centre. There are twelve lights in the window, which is an air-tight show case, and illustrates how universally the electric light can be applied. In the workshops the lights are fitted to universal jointed brackets and pendants of practical designs, each having its own switch.

THE PROPOSED ELECTRIC RAILWAY AT GREAT YARMOUTH.—The scheme of the electric railway has collapsed, says the Great Yarmouth *Independent*, so far as running it upon the Drive is concerned. The proposal was rejected by a majority of two, a result which would not have been achieved but for the absence of some of the members of the Lands Committee who were in favour of the scheme, and who probably absented themselves from the council meeting in the belief that the adoption of the report was a certain thing. Had these individuals been present Mr. Binko's application would no doubt have been acceded to. It is to be hoped that this gentleman, who of course was considerably disappointed at the unexpected turn of affairs, will accept the terms of the resolution passed at the council meeting, and construct the railway along the North Beach from the Britannia Pier to the North Battery. It might also be that the council, when they saw it at work, would withdraw their objection to an electric railway on the Drive, and that next summer the scheme may be carried out.

ELECTRIC LIGHTING AT WIMBLEDON.—At the annual meeting of the members of the Association of Municipal and Sanitary Engineers and Surveyors, a paper was read by Mr. Santo Crimp on the recent electric lighting trials at Wimbledon. The area of Wimbledon is 3,220 acres, and the population exceeds 20,000, the ratable value being £170,000. The number of street lights is 361. The street illuminant was originally gas, but the high rate charged by the company led the local authority to seek other means. Seventy-six incandescent lights were worked for eight weeks an average of six hours per night, at a cost of 0·378 of a penny per 25 candle-power light per hour. The cost for attendance would have been ample for 400 lights, which, if employed, would have reduced the expense to 0·2 of a penny per lamp per hour. The author of the paper, who is the surveyor of the district, reports this form of light to be devoid of all the defects of oil and gas,

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the light is absolutely steady ; it can be turned on or off or regulated at pleasure from a single station, and is independent of the weather. All the street lamps at Wimbledon have been lighted for three years by oil, which is stated to be generally approved of by the inhabitants, and to be far cheaper than gas.

ELECTRICITY IN THE MENAGERIE.—An American contemporary says :—"Nearly every day some new use is found for electricity, and one of the most recent applications of this power is in the interest of the professional tamers of wild animals. The inventor is a tamer himself, and his instrument is an apparatus shaped like a stick and highly charged with electricity. When the animals become unruly he gives them shocks from this battery, and the effects are said to be instantaneous. On experiment three of his lions immediately showed signs of the greatest terror. They were seized with trembling and growled fitfully. The tiger was more quickly subdued, became stupefied, and crouched in a corner of the cage. Bruin was more refractory to the electricity, which seemed scarcely to affect him. He would growl and show his teeth, but was subdued after repeated discharges. The most astonishing effects, however, were perceptible in the boa constrictor. On receiving the discharge the specimen from Cayenne, nearly 20ft. in length, became at once paralysed, and remained motionless for six hours afterwards. When he recovered he showed signs of helplessness for three whole days. Finally the elephant, on being electrified by a touch of the stick upon the tip of his trunk, set up a series of wild cries, and became so frantic that the tamer feared he would break his heavy iron chain."

THE ELECTRIC LIGHT AT KIMBERLEY, SOUTH AFRICA.—On the occasion of a fancy dress ball, which during the past month was given in the Theatre Royal at Kimberley, the two ball rooms, the smoking room, and the middle room were lighted by electricity. Mr. Cousens, the electrician, spared no pains, says the *Kimberley Daily Independent*, to place his department beyond the reach of cavil, and though the shower of congratulations which he received must have been embarrassing they were nevertheless well deserved. Hanging from the roof were five large arc lamps, which by themselves shed radiance around. To this fine display was added 38 small incandescent lights, which were distributed in the form of arches over the various entrances, over the main arch, and at the back of the dais. These latter gave the place a kind of glorified Arabian nights' look, when Haroun-al-Raschid was lord at Bagdad. Many were astonished at the presence of the electric light, and its appearance was not obtained without a great deal of trouble on the part of Mr. Cousens. The spare machine was removed from the electric lighting head-quarters at the Municipal Compound and placed in Tarry's shop, about 300 yards behind the theatre. The whole was worked by one of Mr. Tarry's engines. One of the guests, who was got up as Aladdin, wore an incandescent light on his turban that flashed all over the place, and rendered him more than conspicuous. The idea, says our contemporary, to whom such things are novel, was certainly a clever adaptation of electricity.

ELECTRIC LIGHT ON S.S. "BARRUMBEET" AND "CORANGAMITE."—As showing the enterprise of the owners in adopting the latest improvements, these ships have been fitted up with the electric light throughout, in addition to and quite independent of the ordinary lamps. The installation is probably one of the most complete ever fitted in a steamer, the light being applied not only to all saloons, state rooms, passages, fore cabins, seamen's forecastles, pantries, galleys, store and lamp rooms, engine rooms, stoke-holes and shaft tunnels, but also to the side and masthead lights ; and a number of lamps, including hoisting lanterns, are arranged about the decks, which can be used either for lighting the decks as a promenade, or for lighting up the hatchways, decks, machinery, &c., when loading or discharging cargo at night. A horizontal double cylinder Tangye engine is placed in the engine room, driving an Andrews patent "Woodside" dynamo at 425 revolutions per minute, which provides current for the 160 lamps. This machine has been specially designed for ship use. It can be taken to pieces with little labour and in confined places. The current is divided into five main circuits by a switch-board placed close to the engine. The first circuit supplies light to the whole of the first-class accommodation, and is again divided into three circuits by a switch in the pantry, viz., one for the saloon, one for all sleeping apartments, and a night circuit supplying the lights in the passages, lavatories, &c. The second circuit supplies the officers' quarters, the third the second class cabin and seamen, also subdivided like the first, the fourth the engine rooms, and the fifth the decks and cargo lights. The light in the saloons has a most pleasing effect, and we have no doubt will be appreciated by the passengers. The installation has been carried out in a most efficient manner by Messrs. J. D. F. Andrews and Co., Woodside Electric Works, Glasgow, under the direction of Mr. M'Kay, superintendent for the owners. The pneumatic bells throughout the two ships have been fitted up by the same firm.

EARTHQUAKES.—The movement of the earth seems to be more or less general in its character. A violent shock has been felt at Doui, Dognies, and Flers en Escrebieux in France. The phenomenon was preceded by a rumbling sound, which is described as having resembled the distant report of a cannon. It occurred at ten minutes past 4 o'clock in the morning, when most of the inhabitants were still in bed. Many of them were awakened by the shock, and were so alarmed that they rushed in their night clothes out of their houses into the streets and roads. The oscillation of the ground stopped a great many of the clocks. No very serious damage was done. A distinct shock of earthquake of a few seconds' duration has also been experienced in Melbourne. The shipping in the bay was visibly agitated, and at the Observatory a number of instruments were disarranged and some of the lighter ones overturned. The shock was chiefly confined to the northern and southern suburbs, the eastern and western hardly experiencing the phenomenon. Telegrams from Gippsland stated that the shock had been severely felt throughout the province, and also at Wilson's Promontory. At Gabo Island the shock had also been felt. A telegram from Simla, which was dated June 29, announced that after an interval of three days, during which there was no seismic disturbance, shocks of earthquake occurred at Srinagar with renewed violence on June 24 and 25.—Scotland has also experienced several shocks. The Fort William correspondent of the Press Association telegraphs :—"Another shock of earthquake was felt in four different places in Loch Aber on Saturday. At Blarmaefoldoch, a crofter, while hoeing potatoes, heard a strange sound, and felt the ground trembling. He stood still while it passed away. At Lochulside a farmer coming with a horse and cart felt the vibration for about two minutes. At Banavie several persons felt the shock quite distinctly, and at Fort William two joiners at work felt the floor shaking, and some glass in the shop was rattled." The Carlisle correspondent of the Central News telegraphed on Wednesday night :—"A severe shock of earthquake was felt in the Lake District to-day. At Grasmere and at Ambleside

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much alarm was caused, the shocks being accompanied by a noise like thunder."

THE TELEPHONE SYSTEM IN INVERNESS.—The rapid and easy means of intercommunication offered by the telephone, and the advantages of its exchange system, through which conversations can be carried on almost as easily by persons miles apart as between those sitting in the same room, has led to a very considerable extension of the National Telephone Company's system in Inverness. The central office in Union-street was opened in the beginning of the present year, with a membership of forty-two subscribers, with call offices at Union-street, Muirtown, the Thornbush, and at Kessock Ferry, for the use of the general public. Since the issue of the first list for the Inverness District in January last, the manager, Mr. J. Townsend, has secured no fewer than sixteen new subscribers, and opened a new call office at the Slaughter House for the benefit of the fleshers and others. The new list, which has just been issued to subscribers, shows that there are now 63 places of business connected with the Exchange, 58 of these being subscribers' premises, and five call offices. The wires of the company extend all over the town—from the Exchange in Union-street to Kessock Ferry on the one hand, and to Annfield on the other; and from the Distillery at Millburn to Muirtown Wharf. In order to enable the operator at the central office to "switch on" any two subscribers rapidly, all the members have a wire direct to the Exchange, so that the company in establishing communication between their members have had to put up wires extending over a circuit of 27 miles. No fewer than 71 telephones are in daily use in Inverness, and we are informed that the record kept of the calls by each subscriber shows that on an average each receives about eight messages by telephone per day. At the opening of the system in January last, the number of messages averaged about 300 per day. The number has in the interval almost doubled. Last week no fewer than 4,000 messages were transmitted, or an average of over 600 per day. This shows that the advantages of the system are in every way appreciated by the subscribers, and that the telephone is being largely used in the way of business. The call offices which have been established for the use of subscribers and the general public at Union-street, the Thornbush, Kessock Ferry, Muirtown, and the Slaughter House have been found of great service, and have been largely taken advantage of. Efforts are being made to still further extend the system in Inverness.

INCIDENTS OF THE BATTLE OF BANTRY BAY.—During the course of the engagement a small flotilla was detached to attack the "Hotspur," which, lying close in shore, was entrusted with the task of protecting the torpedo field, and right well she did it, sweeping her electric light swiftly all about, and bringing her guns to bear on every object that came within the brilliant beams. No sooner had the attack commenced than a continuous rifle fire was opened all along the line from boats moored by the boom, from marines lining an embankment on the shore of Bere Island, from bulwarks and rigging of gunboats and corvettes. Batteries hitherto masked belched forth an enfilading fire from both flanks on the boats as they came across the broad path of moonlight, or were exposed by the searching gleam of the electric lamps. For more than five minutes in one case a group of steam launches and rowing pinnaces was exposed to the hail of case shot without being able to escape from the fierce white light that followed them wherever they went. At this moment the scene was one of probably unexampled magnificence. On all sides the black hills around were lurid with what appeared to be a seething cauldron of fire and smoke; blue, green, and red lights flickered, or darted hither and thither, and the cold white beams of the shifting electric light shone through the turmoil, illuminating, now the boom with all its formidable defences, now a flying torpedo boat, and now a steam pinnace, rigged for jumping obstructions, and rushing head on into the line of spitting flame and cloud that betokened the position of the defending boat. The "Polyhemus" had to run the gauntlet of a formidable array of defences, and one would have thought her chances of getting through without being put over almost hopeless. Going a mile or two outside the harbour mouth, she gradually got up speed as she circled round and round like an eagle in flight ready to swoop on its prey. As her speed increased up to seventeen knots or more, the sea at her prow rose higher and higher, breaking in a white seething ridge from which flakes of foam slid down the green steep wave. Then, as she turned head to wind, the spray dashed high above her forecastle, and the sunlight fell in a shower of rainbow hues. Then pointing straight for the defensive works she seemed to skim over the water. As she passed across the field of submarine mines several electric contact batteries exploded, showing that they had been well laid and had sustained no injury during their long immersion in water that has been by no means undisturbed.

DECOMPOSITION OF CARBONIC ACID GAS BY THE ELECTRIC SPARK.—Various chemists have investigated the decomposition of carbonic acid by the electric spark. Experiments having shown that no explosion is propagated by a spark in a mixture of carbonic oxide and oxygen dried by standing over anhydrous phosphoric acid, it seemed of interest to repeat the experiments on the decomposition of carbonic acid when dried in a similar manner. Carbonic acid dried over anhydrous phosphoric acid was submitted to a series of induction sparks in a eudiometer by means of a chain composed of short pieces of platinum fused into small glass bulbs. The amount of decomposition varied from time to time, approaching no fixed limit. Similar results were found on introducing a Leyden jar into the secondary circuit of the Ruhmkorff, but the amount of decomposition was less. On passing a series of induction sparks through a dried mixture of carbonic oxide and oxygen partial combination gradually took place, but no fixed limit was reached. Two similar eudiometers were prepared and fitted with wires made of an alloy of platinum and iridium, each wire ending in a bulb about 2 mm. in diameter. The bulbs were brought to the same distance apart in the two tubes. On bringing an equal volume of dried carbonic acid into the two tubes, and sending a series of sparks from one Ruhmkorff coil through both tubes at the same time, the gases in the two vessels were found to be equally affected, their volumes varying exactly together so long as the pressure was kept the same in the two tubes. The more feeble the spark the greater was the decomposition of the carbonic acid found to be. When 100 volumes of dried carbonic acid were brought into one tube, and 150 volumes of a dried mixture of carbonic oxide and oxygen were brought into the other, and a series of sparks were passed through both from the same coil, the volume of carbonic acid increased, and the volume of carbonic oxide and oxygen diminished, until after some hours they became equal. On a further prolonged passage of the spark the two volumes altered together, sometimes increasing and sometimes diminishing, as the nature of the spark varied. A coil of fine platinum wire was heated by an electric current to whiteness in dried carbonic acid. No permanent alteration of volume was produced. When a similar coil of platinum wire was heated in a mixture of dried carbonic oxide and oxygen, it glowed intensely for some minutes, and complete combustion was found to have taken place between the two gases. No flame was visible round the wires.

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COLLIERY EXPLOSIONS.—A very interesting correspondence upon the above subject appeared in a recent issue of *The Times*. Lord Thurlow, whose knowledge of electric lighting renders his remarks especially valuable, says :—"It is to be hoped that your remarks on the Clifton Hall Colliery explosion will open the eyes of the Home Office, the Board of Trade, colliery owners, and all concerned to the necessity of making electric lighting compulsory in all coal workings. No mechanical or scientific difficulties exist, and no special lamp has to be invented, as the ordinary 20 candle-power incandescent lamp is perfection for the purpose. A small first cost need only be incurred, and a direct and immediate saving would be effected, the cost of electric lighting being less than one-half that of oil, with ten times the efficiency, besides not vitiating the atmosphere, to which advantages add the future absence of periodical explosions in 'fiery' pits, which, you tell us, have cost this country 40,000 lives and over a million of men injured during the last 30 years, not taking into consideration the support of their widows and orphans. I will not ask for more space to-day, or I might urge the almost equal claims to electric lighting of flour, cotton, and other mills where the atmosphere is charged with combustible or highly inflammable dust." Another correspondent, Mr. Radcliffe Ward, also writes as follows :—"One point you bring strongly forward, viz., that it is to electricity that we must look for a light which, while perfectly safe, is also sufficiently brilliant to give the miner all the light he wants. As one connected with the electric light from its industrial birth, I feel the greatest interest in what I am certain might be made one of its greatest and most profitable uses from every point of view, and this I desire to state, viz., that during the last two years I have had occasion to examine both into secondary and primary batteries, the former which, if put into proper shape, could certainly furnish a satisfactory portable miner's lamp. As regards accumulators, there is no question whatever that portable (and for mining purposes the lamps must be portable and not worked off wires exclusively) miners' lamps can be made, and their working cost, charged from a motive power at the pits, costing an almost inappreciable amount, would be far less than the existing method of illumination. It is a process that appeals to one's common sense that, where power is so cheap and abundant as on a coalpit, a method of lighting whose chief consumed material is power should be the means *par excellence*. And there are literally no serious difficulties of detail to overcome which stand in the way of a portable electric lamp, charging and working plant being attached to every fiery mine in the country. Distinctly it is a subject those having the direct appliances to work with should lose no time about. Accumulator and lamp manufacturers are those from whom we have a right to expect the necessary apparatus. And as regards primary batteries I believe that even with these it is possible to get a satisfactory portable lamp, and there is at least one which promises to be sufficiently handy and portable for this purpose."

RESEARCHES ON THE DETERMINATION OF THE DIELECTRIC CONSTANT OF GASES. *Phil. Mag.*—Dr. Ignaz Klemencic, of the University of Graz, has determined the dielectric constant of some gases and vapours by the following method:—A large condenser, consisting of thirty nickel-plated brass circular plates of 25·76 cm. diameter, was put upon a plate and covered by a glass globe fitting air-tight to the plate. The plates of the condenser were separated from each other by small ebonite plates, 0·89 mm. thick; but the rest of the space could be filled with air or any other desired gas. The density of this dielectric medium could be varied within certain limits, and the pressure read off upon a manometer. The condenser was placed in communication with an air-pump and with large glass globes by means of tubes provided with taps. The condenser and glass globes could be exhausted to a tolerably low pressure, and it was also possible by means of a branch tube to fill the condenser with any gas at a high pressure. When it was necessary to exhaust the condenser rapidly, it was simply placed in communication with the exhausted glass globes. This condenser was charged 64 times in every second, and discharged as frequently through a sensitive galvanometer by the use of a tuning-fork, from a powerful battery of 22 small Bunsen elements with solution of potassium bichromate. The deflection of the galvanometer needle thus produced is, as is well known, a measure of the capacity of the condenser. If the electromotive force of the charging battery and the frequency with which it is charged and discharged remain the same, any change in the capacity of the condenser produces a corresponding change in the deflection of the galvanometer. If the dielectric constant of the medium varies with the density, then every change in the pressure within the condenser must produce a change in the position of the galvanometer needle. The deflection produced in the present case by the discharge of the condenser was much too large to render possible the observation of such a difference in position; it was therefore necessary to compensate this deflection, *i.e.*, by means of an equal opposite action upon the galvanometer needle. Of the various possible modes of compensation the author employed that of a constant current. A weaker battery (compensation battery of 4 Daniell cells) was employed to send a current through a large resistance, and through the coil of the galvanometer in the direction required to produce a deflection opposite to that given by the discharges of the condenser. By altering the large resistance of the compensating current, it was easy to arrange that the needle should remain in its position of equilibrium under the simultaneous action of the two currents. If this adjustment had been made for a definite capacity of the condenser, and if then only the density of the dielectric medium was varied, a deflection of the galvanometer needle was observed, due to the change in the capacity of the condenser produced by the change in density, and consequently in the dielectric constant of the medium. The ratio of the dielectric constants for two different densities of the medium may be calculated from the easily determined deflection produced by the compensating current and the observed deflection. In this calculation it is only necessary to take account of the circumstance that a small part of the condenser discharge passes through the compensation-circuit, and not through the galvanometer. As is well known, both Prof. Boltzmann and Messrs. Ayrton and Perry have employed the electrometer for their investigations on this subject. The condenser was charged for a much longer period than in the present case; and this constitutes an essential difference between the two methods. It is a great advantage of the galvanometric method that good insulation is by no means so necessary as with the electrometric method, and thus one of the chief difficulties which such measurements offer is avoided. The question whether the accuracy of the results is disturbed by electricity produced by the friction of the gas admitted to the condenser does not here arise. Besides the seven gases already examined by Prof. Boltzmann, the author has also examined the dielectric constant of five vapours. The results obtained with the seven gases and the vapour of carbon disulphide agree very well with the determination of Boltzman, and with the electro-magnetic theory of light. The dielectric constants of the remaining vapours do not satisfy the conditions given by this theory.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 79.)

Dielectric Displacement and Absorption.

The most remarkable and distinguishing feature of Maxwell's theory of electromagnetism is his dielectric current, whose introduction into the theory gives us a dynamically complete system, with propagation of disturbances in time through the medium surrounding and between conductors, doing away with the mathematically expressible, but practically unimaginable, instantaneous actions of currents upon one another at a distance, and similar, though more simply expressible, instantaneous forces between imaginary accumulations of the "electric fluid." Some might say that the distinguishing feature is his dielectric displacement. But it is scarcely that, strictly. For that a dielectric medium was put into a state of polarisation by electric force was Faraday's idea, and this polarisation is only another name for electric displacement. Again, Sir W. Thomson had given mathematical expression to the idea of polarisation in a dielectric; the statement $D = cE/4\pi$, expressing the displacement or polarisation in terms of the electric force, had been given in a somewhat similar form by him. Whether we call it displacement or polarisation does not matter; the important step made by Maxwell was the recognition that changes in the intensity of polarisation constitute a real electric current (though without dissipation of energy in Joule heating), and that the electric current, whether conductive or not, is always continuous. Accumulations are done away with altogether, and with their abolition the fluid or fluids become meaningless.

As regards the term displacement, though it may be objected to as misleading, suggesting a real displacement in a certain direction, whereas the phenomenon, though undoubtedly having some directional peculiarity, is probably not of the nature of a simple displacement, just as the conductive current is not the motion of a fluid through a wire, yet on the other hand, it is to be remarked that the term current is firmly fixed in use, and, to accompany it, there could be no better term than displacement. The time-integral of the current, from the zero configuration, in a dielectric, is the displacement; conversely, the current is the time-variation of the displacement. It would therefore be a pity to abolish the term displacement, unless we simultaneously abolish current; and it would be hard to find two words which fit together so well.

If we define the displacement as the time-integral of the current anywhere, not merely in a non-conducting dielectric, the current is the time-variation of the displacement anywhere. The displacement, reckoned from a proper zero at a certain time (any time when there was no dielectric displacement) is then, like Maxwell's true current, a vector magnitude of no convergence at every moment and everywhere. In some special investigations this is useful. We may then speak of conductive displacement and elastic displacement, but I believe in general it is best to confine the term displacement to elastic displacement (in a dielectric) only, unless we are careful to qualify the word by a preliminary adjective. In the absence of any qualification displacement in a dielectric is meant, and, should it be also conducting, the conductive displacement must be separately reckoned.

The difference between Maxwell's and older views regarding electricity and the electric current is instructively brought into prominence by making a small change in Maxwell's system, or rather in taking an imaginably possible, though really untrue, special case of the same. Put $c = 0$ everywhere. That is, stop all elastic displacement. Make no other change. The electric current is left continuous, and is now necessarily confined to conductors only, and at their surfaces must always be tangential. But there will still be magnetic force and induction, mutual forces between circuits, induction of one circuit on another, and there will still be transfer of energy through the medium from sources to sinks of energy. We have simply done away with the "elastic yielding of the connecting mechanism." The velocity of propagation of waves, as the specific capacity is imagined to be reduced to nothing, becomes infinitely great, instead of being only that of light. The theory of the induction of linear circuits becomes that given by Maxwell, wherein dielectric displacement is ignored. No effect is produced upon the distribution of steady current set up by steady impressed forces, but in the first transient states there are great changes. In a linear circuit, for example, the current is now absolutely constrained to keep in the conductor, so that there can be no surface charges or static retardation. Though there is no electrification, there is still electric potential. But we cannot charge a condenser. Therein lies the difference from reality. To be able to do this, without employing Maxwell's dielectric current, we are necessitated to suppose that the current is not continuous, but that it is the real motion of something that can accumulate in places. We are also obliged to change the relation between magnetic force and current, as it implies continuity of the current everywhere. Many other changes are also required to make a consistent system, for one change necessitates another, and we shall ultimately come to something extremely different from Maxwell's system.

In view of the extreme relative simplicity of Maxwell's views, and their completeness without any artificial contrivances to save appearances, and in their modernness, referring to modern views regarding action at a distance, one is almost constrained to believe that the dielectric current, the really essential part of Maxwell's theory, is not merely an invention but a reality, and that Maxwell's theory, or something very like it, is *the* theory of electricity, all others being makeshifts, and that it is the basis upon which all future additions will have to rest, if they are to have any claims to permanency.

Electric displacement is primarily a phenomenon of the ether. Ether is perfectly elastic. It must be so if there be no absorption of the energy of radiations during transmission through space. This conclusion is of course independent of Maxwell's view of light being itself an electro-magnetic disturbance. If the energy of displacement be potential energy, the displacement, whatever it really be, is of a perfectly elastic character, in the absence of ordinary matter.

But when electric displacement occurs in a solid dielectric, if there be, as there must be, mutual influence between the ether and matter, we may expect the elastic properties of the matter to be communicated, apparently, to the ether. Thus, no solid is perfectly elastic, and, consequently, electric displacement in a solid dielectric is not perfectly elastic, as it is assumed to be in the formula $D = cE/4\pi$, with c invariable at any place, the linear relation between the displacement and the electric force.

A solid, under the influence of externally-applied force, is strained. If the strain be under a certain magnitude it is assumed to be perfectly elastic, so that whilst the stress remains steady the strain does not change; and on the removal of all stress the strain entirely ceases. But, in reality, if a certain applied force deform an elastic solid, and the force be kept on, the deformation slowly increases, as if the elasticity slowly decreased. And on the removal of the applied force the original zero configuration is not immediately recovered. The residual deformation will then slowly subside. If, after the first approximate return to the original state, the body be, by constraint, prevented from changing shape, the solid, which at first did not react against the constraint, will gradually do so, so that on the removal of the constraint, a second return, in a lump, towards the original configuration, will take place.

Remembering that a dielectric under electric stress is in a state of strain, we may expect there to be a corresponding electrical phenomenon. The displacement produced by a given constant impressed force should be, at first, appreciably quite elastic, but should thereafter slowly increase. On the removal of the impressed force the original displacement should at once subside, leaving a small residual displacement which should subside very slowly, as it came on. Or, if the residual displacement be fixed, so that it cannot subside, it should appear to gradually come back into existence, as elastic displacement

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referred to the original zero, so that on the removal of the constraint a second sudden subsidence should take place.

This is what happens in the phenomenon of electric absorption in a perfectly insulating dielectric. Whether it be really true or not that a part of the electric displacement becomes intrinsic by reason of some *quasi*-rigid connection with a similar phenomenon taking place in the strained solid, there is no doubt that there is a remarkable resemblance in the details of the two cases. That the presence of the matter causes the displacement to be increased from what it would be with the same electric force in ether is a separate matter, as this refers to elastic displacement. ($c>1$ in all dielectrics, if unity in vacuo).

An elastic spring is therefore the most correct analogue to a condenser when we wish to make up a mechanical illustration of the electro-elastic properties of a solid dielectric. We may, for instance, take a flat spring, clamp it firmly at one end, and apply pressure or pull to the free end in a direction perpendicular to its flat sides. Consider the applied force to represent the E.M.F. of a battery joined to a condenser, and the displacement of the free end of the spring to represent the electric displacement in the condenser. The displacement will be proportional to the force, in both cases, approximately, and if by any suitable means we magnify, mechanically or optically, the motions of the spring under varied circumstances, we shall see a corresponding set of phenomena to those occurring under similarly varied circumstances in the case of the electric displacement.

But an illustration, which, though less exact, is more easily followed by the mind's eye, when we cannot render visible the absorption properties of a spring, is that which occurred to me when first making acquaintance with Maxwell's mechanical illustration, the parallel vertical tubes, containing water. This being rather complex, I substituted the following :—Electric displacement in a condenser is represented by the actual displacement of a piston in a cylinder from its position of natural equilibrium in the middle thereof, when the cylinder is perfectly air-tight and contains an equal amount of air on each side. To give motion to the piston, rods may be attached to it, passing through holes in the closed ends of the cylinder. Call the ends of these rods, outside the cylinder, a and b, and the two corresponding air spaces in the cylinder A and B, a and A being to the left, b and B to the right. If pressure be applied to a or a pull to b, or both, the piston will be displaced from left to right, and small displacements will be proportional to the corresponding applied forces.

The displacement of the piston corresponds to the total electric displacement in a condenser ; the applied force to the E.M.F. of the battery on the condenser ; the back pressure of the rod a to the difference of potential of the condenser plates ; the displacement of a inward to the positive charge, and of b outward to the equal negative charge. Insulation of the condenser is represented by fixing a or b so that the displacement cannot change.

If we like to carry the illustration further, we may cause the rods a and b to meet with frictional resistance when moving proportional to the speed of their motion. This speed will correspond to the strength of current, and the coefficient of friction to the resistance of the conductor joining the poles of the condenser. We may go further, and suppose the mass of the piston and rods to represent the self-induction coefficient of the electric circuit, thus obtaining an illustration of the oscillatory discharge which occurs with suitable values of the resistance, capacity and self-induction. Although this analogy, which is well known in one form or another, is very close, and therefore educationally valuable, it should be remembered that it suggests that the momentum of an electric current is that of matter moving with the current, or of the current itself, if it be the motion of matter, having therefore necessarily momentum. So far it is apt to mislead ; for electricity has no momentum itself or kinetic energy. The momentum is that of the magnetic induction, or is proportional thereto, and it, and the (nominal) energy of the current, exist wherever there is magnetic induction, not merely in the wire.

To imitate absorption, make the piston very slightly leaky. Then if a be pushed in by a steady pressure, the first displacement of the piston is elastic with reference to the proper zero, the middle of the cylinder. But air then leaks slowly from B to A on account of the increased pressure in B, which causes the back pressure of a to decrease, and allows the same applied force to slowly increase the displacement. (This corresponds to the slow continuous increase of electric displacement in a condenser when a constant battery is kept on.) Or, if a be fixed, the back pressure will slowly fall whilst the displacement remains constant. (If the condenser be insulated, its difference of potential will fall whilst its charge remains constant.) Unfix a ; the first return equals the first displacement, approximately, but there is left a small displacement which will slowly subside if the piston-rods be free ; or if a be fixed a pressure at a will be gradually brought on by the slow leakage from A to B, so that a second sudden motion of the piston back to its proper zero can be got on unfixing a. (Remove the battery, but close the circuit still ; the first discharge will approximately equal the first charge, but there is left a small charge which will slowly subside if the circuit remain closed ; or, if it be insulated, a difference of potential of the same kind as before will gradually come on, so that a second discharge can be got on again closing the circuit.)

To instantly remove the displacement of the piston after leakage has occurred, we must apply an opposite force, a pressure at b or pull at a of the right amount to bring the piston to the middle. If we then fix a and leave the thing to itself the pressure of the rod at b will gradually subside. Similarly if we, after absorption has occurred in a condenser, and the first discharge has been taken, charge it oppositely by a reverse E.M.F. of the right amount to make the real displacement zero, and leave the condenser insulated, the apparent opposite charge will gradually disappear.

Since the first discharge equals the first charge we may regard the capacity of the condenser as being constant, and the displacement at any moment to consist of two parts, first that due to the battery E.M.F., which can be got rid of at any moment, and next a temporary intrinsic displacement which is kept up by impressed electric force in the dielectric itself arising from its altered structure, or the changed zero of its elastic deformation. The displacement due to a certain total E.M.F. in the circuit is the same however it be distributed, whether in the conductor or dielectric, if, over any cross section, it be evenly distributed. But only the part in the conductor causes difference of potential in a steady state between the ends of the conductor, so that the intrinsic displacement due to internal impressed force gives no external sign of its existence until, by the removal of the impressed force, difference of potential is developed between the terminals of the condenser.

In the case of the piston in the cylinder, the intrinsic force keeping up displacement of the piston after the rods have been set free is the pressure of air in A against the piston from left to right which, had it not been for the leakage, would have been in B, and have pressed the piston the other way.

Another effect may be mentioned. If the dielectric of the condenser be of such a nature that its capacity increases or decreases with the temperature, then, on suddenly charging it, there will be a cooling or a heating effect produced in the dielectric. This has also its parallels in the metal spring and "spring of the air" illustrations.

Intrinsic displacement in a dielectric, without conducting matter surrounding it, to render the displacement wholly latent, has also some interesting features, which will be next considered.

(To be continued.)

The Eastern and South African Telegraph Company notify that the coupons due on the 1st inst. on their Five per Cent Mortgage Debentures, will be paid on and after that date at the banking house of Messrs. Barclay, Bevan & Co., Lombard-st.

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SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Within the last eighteen months a very considerable amount of work, on a more or less extended experimental scale, has been devoted to the solution of the questions in relation to secondary batteries, which have forced themselves on the attention of practical electricians. This work has been attended with fairly commensurate results; and, indeed, great progress has been made, although this cannot be said to have been yet realised in practice. Readers of the current scientific literature during the above-mentioned period can scarcely have gathered therefrom any intimation of this progress; and until quite recently, when my friend and old pupil, Mr. F. G. Howard, read his paper to the students of the Institution of Civil Engineers, there was a noticeable dearth of all communications in relation to secondary batteries. Some of the causes of this dearth are still existent. Many workers are too busy with experimental verifications and practical developments to be able to devote time to the writing of papers; and for prudential reasons they are bound, moreover, to keep to themselves, for the present, the results of recent investigations. Mr. Howard deserves the credit of having directed renewed attention to an important subject; but his paper, retrospective and dealing with what is already semi-obsolete, or likely to become so, requires to be supplemented by one more prospective in character, and placing the student more *au courant* with the present aspect of the main questions involved—such a paper, for instance, as might be written by another young friend and old pupil of mine, Mr. W. H. Tasker. For the reasons to which I have adverted it may be some time, however, before such a paper can be forthcoming.

At the present time it may be useful, in the first place, to refer critically and briefly to a few points involved in Mr. Howard's paper.

(*a*) It is not an accurate description of the electro-chemical and chemical effects produced in "running down" a lead secondary battery in an electrolyte of dilute sulphuric acid to say that "The result is the reduction of the peroxide of lead on the one plate to oxide, and then to sulphate of lead from the presence of the sulphuric acid in the solution; and of the spongy lead to sulphate of lead." The most casual examination of the "spent" negative element of such a battery is sufficient to show that the active material has certainly not been converted into a white substance such as sulphate of lead—a very bad conductor of electricity, and affected by electrolysis only with difficulty. And the fact that no oxide (monoxide) of lead can be produced by the effect of the oxidation of the lead positive element is confirmed both by theory and by observation. The spent negative material always contains, it is true, some sulphate of lead; but it is essentially a compound analogous to minium or red lead, and, like this body, variable in composition* according to circumstances. In a properly worked battery, but little sulphate of lead should be produced in the cathode of discharge. Although (*meâ culpâ*) I have never had the industry to carry out a series of analyses of spent negatives, and have hitherto failed to induce any of those who are commercially interested in secondary batteries to have such analyses made by chemists with time at their command—in other words, although I am almost as ignorant on the matter as any of my *confrères*—I have, from certain observations, come to the conclusion that the spent negative material in a carefully worked battery should approximate to the composition represented by Pb_2O_3. In regard to the positive element in a lead secondary battery, I cannot go with Mr. Howard further than to admit that the active material (spongy lead) is *partly* converted into sulphate of lead. An experiment with a couple of E.P.S. grids from which the spent material is removed and replaced by sulphate of lead would no doubt modify the notions held by some electricians in relation to the chemistry of the secondary battery.

(*b*) Referring to Mr. Howard's table of storage capacity, the work per lb. average of lead that could be stored in a theoretically perfect lead secondary battery (consisting wholly of active material) cannot be estimated as higher than 207,000 foot-pounds. The higher value of 360,000 foot-pounds is evidently based upon the assumption that one equivalent of lead peroxide would, at least theoretically, suffice for the oxidation by electrolysis of one pound of metallic lead, the potential difference being two volts during the whole period of the reduction of $Pb\,O_2$ to $Pb\,O$. But it is very certain that no such assumption can be allowed. We cannot accept the equation

$$Pb + Pb\,O_2 + 2\,H_2S\,O_4 = 2\,Pb\,S\,O_4 + 2\,H_2O$$

as representing what took place during the discharge. We are forced to admit that, even theoretically, *two* equivalents of lead peroxide are requisite for the electrolytic oxidation of one pound of spongy lead under the potential difference of about two volts. The electro-chemical equation for the lead secondary battery would thus be

$$Pb + 2\,Pb\,O_2 + H_2S\,O_4 = Pb\,S\,O_4 + Pb_2O_3 + H_2O;$$

and three equivalents of lead would be involved in the electrolytic oxidation of one equivalent of this metal.*

(*c*) Mr. Howard is somewhat in error as to the specific gravity of dilute sulphuric acid, constituted of one part of sulphuric acid to nine parts of water; and it may be of importance that this error should be speedily corrected. In no case can the specific gravity of such a mixture be as high as 1·2. If the given proportion be taken by weight, the specific gravity will be about 1·068; if it be taken by volume, the specific gravity will be not higher than 1·13. Roughly, the addition of two parts of sulphuric acid by volume to nine of water gives the specific gravity 1·2.

Mr. Howard in his paper apparently refers to a certain battery, in which the cathode in charging is composed of minium and carbon fragments, as the Crompton-FitzGerald secondary battery. But the letters patent in accordance with which this battery was constructed must be No. 4,178 in the year 1882, granted to FitzGerald and Jones. The letters patent No. 5,159, 1881, granted to Crompton and FitzGerald, do not refer to the use of carbon. The method and processes claimed in the latter have never been adequately tested experimentally.

By the way, electricians do not seem to be generally aware that spongy lead may now be obtained by the Keith process at a fraction over the price of sheet lead.

There is much to be said on the subject of the essential defects of secondary batteries as at present constructed—defects which, whatever Mr. Sellon may think or say, can never be remedied by "care in manufacture and ordinary attention to rules for working." There is, or will be, also, much to be said in regard to the various means whereby these defects may be obviated. I intended to refer in this letter to some very striking results which have been obtained by the use of a certain electrolyte in charging cells of the Planté type; but the present communication has already extended to a sufficient length, and perhaps what I have further to say may not lose in interest by keeping.—Yours, &c.,

DESMOND G. FITZGERALD.

* Three definite compounds, empirically represented by the formulæ Pb_2O_3, Pb_3O_4 and Pb_4O_5, and mixtures of them, are all included under the term minium. The first of the above is a compound of remarkable stability; reagents, such as mercurous nitrate and sulphurous acid, which instantly reduce the peroxide, having no action upon it; whilst on the other hand no plumbic oxide can be separated from it by the solution of potassic hydrate or of the normal plumbic acetate. The second of the above formulæ expresses the most usual composition of red lead

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TO THE EDITOR OF THE ELECTRICIAN.

SIR: I must thank Mr. Sellon for the courteous way in which he has criticised my paper on the above subject, and will endeavour to reply in the same spirit.

Unfortunately it is evidently becoming the fashion, when a discussion is started on the merits of any particular apparatus used in the various branches of electrical engineering, that the manufacturers interested in that apparatus rush into print, and consider it their duty to herald forth to the world, in the

* Mr. Reckenzaun in his letter (p. 119) gives 360,000 foot-pounds as the energy evolved by the oxidation of 1lb. of lead. But this weight of the metal necessarily corresponds to 420,800 coulombs, or 117 ampere hours; and this quantity of electricity, under the potential difference of two volts, must of course be equivalent to 234 watt hours = ·3136 horse-power hours, or 620,928 foot-pounds.

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most extravagant fashion, the perfection of their manufactures, and, not content with this, must needs condemn other manufacturers' goods as useless and utter failures; and also anyone disagreeing with them is immediately stamped as being either ill-informed or inexperienced. Surely this method of advertising their goods cannot be to their interest, as it is liable to make purchasers think twice as to which is really the best article, and whether they are justified in using any of them.

But to return to Mr. Sellon's remarks. I had no intention whatever, as he rightly surmises, of conveying the idea that secondary batteries are almost hopeless; they are far from that, and are every day being more and more improved. Again, that it is only within the last twelve months that any real advancement has taken place in improving the durability of the E.P.S. cells, Mr. Sellon will, I think, admit; and as I wrote my paper more than twelve months ago, I do not think my estimate of their life too low. Undoubtedly, it is quite true, as Mr. Sellon says, that this short life was simply in consequence of carelessness and bad workmanship in the manufacture; but I venture to think that no one is desirous of hearing how long batteries *might* last if properly made, but would preferably know what they are capable of doing as manufactured for commercial purposes.

I am very pleased to hear that Mr. Sellon has some of his original cells still working, and can only wonder why the Electrical Power Storage Company went so astray after taking up the manufacture, as surely they have thus thrown away golden opportunities, both as regards reputation and financial considerations. Mr. Sellon does not apparently consider that "skilled" labour for secondary batteries is necessary; yet he says they require *competent supervision*. How is this to be obtained, say, in a country residence where the owner is not an electrician? Surely an under gardener or labourer could not learn how to keep an installation going without somebody to supervise. I think that the term "skilled" labour has been somewhat misinterpreted; what I intended to convey by the expression was the employment of trained mechanics as opposed to under gardeners or labourers. Of course, where the owner of an installation is master of the subject a boy is often sufficient to keep the plant in working order.

In conclusion, I would add that I do not think that even Mr. Sellon is more convinced than I of the absolute necessity and importance of secondary batteries; and I can only hope that his efforts in this direction may ere long be crowned with that success to which they are so justly entitled.—Yours, &c.,

F. Geere Howard.

Cleveland Works, W., June 30, 1885.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS AT SWINDON.

On Tuesday last, the 30th ult., by the invitation of Mr. C. E. Spagnoletti, M.I.C.E., the president of the Society of Telegraph-Engineers and Electricians, a large party of gentlemen proceeded by special train from the Paddington Station to Swindon, where the works of the Great Western Railway Company are situated. There were about 450 present, amongst whom were Mr. E. Graves and Prof. Hughes, F.R.S., vice-presidents; Mr. W. H. Preece, F.R.S. (past president), Mr. Willoughby Smith (past president), Mr. R. E. Crompton, Prof. George Forbes, F.R.S.E., Mr. W. Crookes, F.R.S., Mr. A. Siemens, Mr. A. Stroh (members of council); Mr. Yoshida (Japanese Commissioner to the International Inventions Exhibition), Colonel the Hon. Le Poer Trench, R.E., Colonel Stotherd, R.E., Colonel R. Murray, Admiral Mayne, C.B., Captain Hall, R.N., Captain Sankey, R.E., Captain M'Evoy, Captain Holden, R.A., Dr. W. H. Stone, Dr. Steet (of the G.P.O.), Prof. H. M'Leod, Mr. G. L. Bristow, Dr. Fleming, Sir Henry Mance, Mr. W. T. Glover, Mr. H. R. Kemp, members; Mr. E. Dunkin, F.R.S. (President R.A.S.), Mr. R. Price-Williams, Mr. A. K. Mackinnon, Sir R. Rawlinson, C.B., Sir George Birdwood, M.D., Prof. G. G. Stokes, F.R.S., Prof. Frankland, F.R.S., Dr. Mann, M.D., Dr. Armstrong, F.R.S., Mr. Phillip Magnus, Mr. E. Woods (Vice-President Institution Civil Engineers), visitors.

On arriving at Swindon the party proceeded to the Drill Hall, where arrangements having been made for their reception, they were entertained at luncheon by Mr. Spagnoletti and several prominent officials of the railway company. After the usual loyal toasts, the President proposed that a vote of thanks be accorded to the Great Western Railway Company for the kindness with which they had placed their extensive premises, in a manner of speaking, at the disposal of the members of the society. This having been unanimously carried and briefly responded to by a gentleman connected with the railway company, the health of the President and veteran electrician of the line was proposed and drunk with a degree of enthusiasm that must, had he not been used to it, have embarrassed the worthy recipient. At the conclusion of the repast, they, under the courteous guidance of the president, had the pleasure of being conducted over the fine engineering works, which, covering 30 acres of ground, are among the largest in England; employing when fully occupied over 7,000 operatives. At periods of pressure they have turned out an engine a week, a carriage a day, and a truck per hour. The shops are nearly all stone built, and are most pleasantly situated in a verdant country, luxuriant with trees. The foundries, rolling mills, steam hammer shed, locomotive and carriage departments, and all the fitting shops were visited, the visitors being exceedingly pleased with the various machine tools employed, and the order and regularity with which these great works are conducted. Special attractions were the carriages used by Her Majesty the Queen and other members of the Royal family, which, elaborately decorated and fitted up, are models of perfection, both in design and construction. A somewhat amusing evidence of the loyalty of electricians was here given, nearly everyone of the party being anxious, even to eagerness, to repose, if but for an instant, upon the couch provided for our Sovereign. A very interesting relic of the earliest days of fast railway travelling, the once celebrated engine of George Stephenson, the "North Star," built in the year 1837, is still to be seen in the loco shed. It looked, and we were informed is still, as good as ever. At about 5:30 p.m. an adjournment was made to the hall, where refreshments of various kinds were provided, and at 6:50 p.m. the party returned to Paddington, where they, with good reason, thanked their genial host for the pleasure he had accorded them.

The Medical Electric Lamp.—The electric lamp used for examining General Grant's throat, says the *Scientific American*, is manufactured by agents of the Edison Light Company. It is mounted on a hard rubber holder, about 7in. long, having a reflector at the lamp end, by which the light can be thrown to any desired angle. The holder is connected by two silk-covered wires to a small storage battery carried in the pocket of the physician. The light is turned on by simply pressing a small button on the rubber holder, and the quantity is governed by another button convenient to the operator. The lamp is inserted in the mouth almost to the palate, with the reflector above the lamp, which throws the light down the throat. The lamp has no unpleasant heat, and gives a light equal to half a sperm candle. The extreme simplicity of the whole appliance makes it very valuable to the physician and dentist.

Electricity as a Reviving Agent.—A case illustrating the power of electricity to stimulate the action of the heart is reported from St. Albans, Vt. A three year old child was by mistake given a dose of morphine, and was so affected by it as to be apparently beyond help. A doctor was called, but to all appearance the child was dead, except that there was an almost imperceptible beat of the heart. An application of electricity was made and continued for four hours, at the end of which time resuscitation was completed and the child lives. During the process of restoration, if the poles of the battery were withdrawn the activity of the heart would subside, and it is very evident that but for the use of electricity death would have ensued.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

VOLUME XIV.

Volume XIV. of "THE ELECTRICIAN," bound in cloth cover, price 10s. 6d, is now ready.

ALSO COVERS FOR BINDING. PRICE 2s.

NOTICE.

We issue this week a Supplement to "The Electrician," in the form of a Primer of Electricity, which Subscribers should obtain GRATIS.

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ELECTRICAL PROSPECTS AND THE CRISIS.

Of the many things that have been unsettled by recent political events electrical interests may not be classed among the foremost; but they are of sufficient importance to call for a word of passing comment, if not of prophecy, at this juncture. We should be counted among the idiots were we to speculate on the possibility of the present "*ad interim*," "stop-gap," "caretaking," "makeshift" Government being in power next year. A Ministry thus lugubriously christened almost before it is born, is, we are publicly assured, doomed to die in infancy. Its sponsors being, as everybody knows, half-inspired and wholly prophetic, nobody dare question their predictions. But we may venture to whisper in an undertone that if this child of sin were to live and prosper for any reasonable length of time, the result might not be altogether unsatisfactory to our clients. We have, for example, hardly anything to hope for from a resuscitation of that supremely virtuous but inconvenient political child who always persisted in having his cake and eating it. The interests involved in the Electric Lighting Act were a cake of this kind. It was a proud achievement of the presiding genius at the Board of Trade; but it was to be eaten all the same as soon as the morsel was done to his liking. The rights of local authorities and the dangers of monopolies were the actuating motives—motives of the purest, no doubt; but with a graceless Minister at the head of that department we might confidently look for a fair share of the cake—the share which erring mortals are entitled to. In other words, it is highly improbable that a Conservative President of the Board of Trade would do other than disapprove of a measure for confiscating the fruits of private enterprise in order to enrich public Bumbledom. Moreover, it is well known that the new Prime Minister is a warm patron of the electric light; and we have it on recent record that he cited Mr. Chamberlain's famous Act as a sample of how the ransoming theory put into practice had stifled and well nigh ruined an industry of great wealth and promise. If the electric light were to burn bluer than ever at the next General Election, Mr. Chamberlain at all events ought not to wonder at it.

It is probable that the Bill giving effect to the international agreement with regard to Submarine Cables will contrive to get passed sometime before the close of the present session. The same cannot be confidently said of the Telegraphs Act Amendment Bill authorising the experiment of a sixpenny rate for telegrams. Signs are not wanting that the governmental caretakers will have enough to do to take care of themselves. They are to be "supported in doing right," and "it is not anticipated that they will do wrong," which can mean no other than that they will be forbidden, even if they attempt, to do anything besides or beyond what their condescending critics do not oppose. It happens that this particular Bill was opposed not only by members who are in opposition, but by at least one member who is now in office, and into whose hands the Bill has actually fallen. Lord John Manners threatened it on the free address question; and he can hardly at once proceed with a measure which settles that question in a way that he disapproves of. On the other hand, he may have equal difficulty in upsetting the arrangements of the permament officials who are to administer the Act, and who presumably approve of its provisions. The retiring Postmaster-General has publicly stated that if the telegraph is to be self-supporting the reform ought to be carried out in the manner devised by him. There is no reason to suppose that his successor regards the telegraph service as a non-paying concern, created for the purpose of subsidising its customers; and we may therefore hope that he will see fit, when in possession of all the facts, to let the Bill pass substantially as introduced. But a decent period will have to elapse before such a conversion can take effect, and, all things considered, the probabilities at present seem to point to the Bill being held over till next year. Its postponement will be the lesser of two evils, for it would be nothing short of a public misfortune if the opportunity were once again lost of placing the telegraph-tariff of this country on a basis which experience elsewhere and commercial principles everywhere point to being the right one. The charge and the scale of words are matters which may be determined by the financial position of the telegraphs for the time being; but the free addresses are a perennial abuse, and must be got rid of—if not this year, next.

Meanwhile, the telephone is making its impression on the revenue of the State telegraphs, and rendering greater the cost of concessions to the public without some compensatory set-off. It is sometimes hinted that the Telephone Companies want to be bought up; the circumstance just referred to certainly points to that arrangement as a conclusion to the present chronic state of rivalry; and the refusal of the late Postmaster-General to accede to the outrageous pretensions of the companies in regard to overhead

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wires will tend in the same direction. Lord John Manners probably will view the encroachments of the telephone with no less disfavour than his immediate predecessor. Conservative Governments, after their expensive purchase of the Telegraphs and their disastrous negotiations with the Water Companies, may be shy of essaying another transaction of the same kind; but if a bargain is to be come to between Telegraph and Telephone it will be a Conservative rather than a Liberal Government that will carry it through. But this is beyond the power of any *ad interim* Government, and we must wait at least till the autumn before anything decisive on this, as on other points, can be foreshadowed.

OHM'S LAW AND POTENTIAL DIFFERENCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The position as regards the heat formula $H = \frac{E^2}{R}$, discussed between Mr. Wilkinson and myself, under the heading of "Blind Mathematics," now requires to be re-stated. I am much obliged to your correspondent for the trouble he has taken in explaining to me how the formula in question is a correct deduction, according to the interpretation of it he has been good enough to give, and how it is practically useful, at least as a rule of thumb; meanwhile, he has probably been sensible of the objections which I continued to urge even after his interpretation. More on these points would scarcely be of public interest.

But Mr. Wilkinson will doubtless have perceived by this time that the original ground on which I charged electricians with mathematical blundering was my different notion as to what really is Ohm's law. And as Mr. Wilkinson has thought well, in his own words, "to lead me back to Ohm's law," I must ask him to tarry there with me awhile, in order to investigate what law has the true and prescriptive right to be called by such a title. And I propose to argue the matter, in the spirit of Socrates, as one who wishes to be corrected if he is in error.

To say that Ohm's law is $C = \frac{E}{R}$ would not be a sufficient answer, until the proper sense of the symbols is defined; and here lies the field of debate. Men of all times would agree that the above formula expresses Ohm's law, but there might be some difference on the question what was signified by E and R respectively. I am surprised to find how many electricians intend by these symbols "the difference of potential (E) between the ends of a resistance (R) carrying a current C."

On referring to Ohm's paper itself, I find that there really is a law framed by him referring to local volts and local resistance, and which, though more complex in its original form, might be rendered from a modern point of view by the symbols $C = \frac{v}{r}$, the small letters being used to denote local conditions.

But the climax of the working is as follows:—

"The second of the preceding equations becomes by the adopted change—

$$S = \frac{A}{L}$$

which is universally valid, and the equality of the greatness of the current at all parts of the circuit is at once evident from its form; it is expressed in words thus:—

"*The greatness of the current in a galvanic circuit is directly proportional to the sum of all the pressures* (spannungen), *and inversely proportional to the entire reduced length of the circuit.*"

The phrase "reduced length" refers to a diagram, and means something like "length in ohms," *i.e.*, resistance. (*Die Galv. Kette.* Dr. G. S. Ohm, p. 36.)

Now, I cannot help feeling that this $S = \frac{A}{L}$ is the formula which $C = \frac{E}{R}$ was originally framed to represent; and is not such a view confirmed by the traditional notion that "Ohm's law" (whatever it be) expresses the relation between three elements, viz., E.M.F., Resistance, and Current? But if, as I presume, E.M.F. is that force or sum of forces which moves the electric current, this element is found only in $C = \frac{E}{R}$ with the meaning of $S = \frac{A}{L}$.

It is only a confused mind that can tell me I am making a distinction without a difference, and that E.M.F. and potential difference are the same thing. To such I reply that as long as we are speaking of a circuit which is "carrying a current C," the E.M.F. is *one* for the whole circuit, just as much as the current strength, whilst potential difference may be detected in infinite variety according as it is reckoned between the terminals or over shorter distances, and meanwhile not one of them all indicates the E.M.F. of that circuit. The only case in which volts indicate E.M.F. is that of a possible circuit yet to be made, and accordingly this indication is given (1) at the insulated terminals of a rheomotor, and (2) at the two derivation points of any intended shunt.

The law of local volts (as I should prefer to term it) which shows the relation of current strength to *external* E.M.F. and *local* resistance, though of great practical utility, does not formulate a fundamental physical relation like the one whose symbols it has usurped, much less are the two laws identical.—Yours, &c.,

E. ALDRED WILLIAMS.

55, Cornwall-road, W., June 30, 1885.

THE TREATMENT OF REFRACTORY GOLD ORES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I was pleased to notice in your issue of the 26th inst., a description of my process for the treatment of refractory gold ores by electrolysis.

Although in the main the description is an accurate one, it might be somewhat misleading from a chemical point of view, as a most important feature of the invention, and its bearing upon the process has not been indicated.

You state that by a secondary reaction a soluble iron compound is formed, which precipitates the gold, and thus prevents its extraction. But by not stating by what means I overcome this reaction, the impression would be conveyed that the gold remains behind in the revolving drum. Were this the case, my process would be of no value whatever. It is just because I can separate the gold from the ore and deposit it outside of the drum at the negative pole in a metallic state that I am enabled to treat successfully, and on a large and practical scale, all those refractory gold ores which have hitherto presented so many difficulties.

In order to prevent the salts of iron and other metals from precipitating the gold, I add the lime at a certain stage of the process. This lime immediately precipitates all the metals in solution with the exception of the gold, which, remaining dissolved, is deposited at the cathode in form of a black slime. The asbestos cloth prevents the gangue, &c., from reaching this pole, and the gold hence remains in a pure state.

The reactions which take place are briefly as follow: Nascent chlorine and nascent oxygen are generated by electrolytic decomposition of an aqueous solution of chloride of sodium, whereby the auriferous pyrites are decomposed. The gold becoming free is converted into auric chloride and is precipitated by the salts of iron, antimony, &c. Addition of lime, consequent precipitation of all metals except gold, which, as long as the solution is kept alkaline, is deposited at the cathode, until the last traces of it are extracted. I have thought it right to give this explanation as the matter has attracted considerable attention, and an erroneous impression might prejudice me.—Yours, &c.,

HENRY R. CASSEL.

London, E.C., June 30, 1885.

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THE ELECTRIC LIGHT AT THE BUCHAREST NATIONAL THEATRE.

(Executed by the Société Electrique Edison, 8, Rue Caumatin, Paris, under the supervision of Francis Jéhl, Electrician to the Société).

Historical Notice.

Bucharest, the capital of Roumania, is a city of about 250,000 inhabitants. It is a cosmopolitan city, with large avenues and streets, luxuries that cannot be obtained better elsewhere. In fact, the area occupied per unit of population is perhaps greater here than in any other European city of like pretensions, the houses being mostly detached. The improvement of the town is principally due to the untiring energy of His Majesty Charles I., King of Roumania, who has built schools, opened academies, and is a great encourager of all that pertains to progress.

Among the finest of the buildings in Bucharest is the Theatre National, situated in "Calca Victoria," the principal street of the city. Some idea of it is obtained from the accompanying illustration.

Fig. 1.—The National Theatre, Bucharest.

The theatre was built about 37 years ago, and has space for about 1,130 people. The theatre is owned by the Municipal Council of the city. It was originally lighted by oil, and then by gas, the latter introduced in 1877. The auditorium consists of a parquet, three floors or rows of boxes, and a gallery. The lighting by gas consisted in the auditorium of a large chandelier, having 282 gas jets. On the first floor, projecting from each box, were 26 chandeliers, each chandelier carrying eight jets, making a total of 208. On the second floor were 20 chandeliers, with eight jets in each, making a total of 160, and on the third floor 22, each having five jets, making 110 in all. The total number of gas jets in the auditorium was, therefore, 760, not including the orchestra. Each jet of gas gave about five candles, equal to a total of 3,800 candles. The ordinary illumination consisted of about 350 jets. The heat caused, however, forced the managers of the theatre to close their season at the end of April. This, of course, prevented many people from amusement, but for the time nothing could be done to ameliorate this obstacle. When, however, electricity was applied to illumination, the matter was discussed by a committee, and they concluded to wait awhile, and inform themselves if this new light was really practical and adaptable. After watching through a period of nearly three years the work at Brünn, where is the first theatre which in Austria was electrically lighted by the Société Electrique Edison, and which has ever since given great satisfaction, it was resolved to light similarly this theatre at Bucharest. Experience has shown that this new light is adaptable to theatrical purposes, and that it has qualities superior to gas, especially when employed in theatres, halls, or any place where there is a gathering of people. It is steady, admits of easy regulation, does not increase the temperature so much as gas, nor emit any sulphurous fumes. It may be made perfectly safe against fire, which is an important consideration with managers of theatres. The Austrian public have not yet forgotten the destructive work one little jet of gas did at the Ring Theatre at Vienna a few years ago. That dark heap of bones buried in the Central Friedhof has done a great deal for the advancement of electric lighting.

The electric lighting of the Bucharest National Theatre is mainly due to the exertions of the Compagnie du Gaz de Bucharest, of which M. Masson, of Paris, is the president, while G. Darlu de Roissy is director and manager of the Company in Bucharest. This company, after receiving several proposals from different electric light companies, adopted the Edison system for its completeness, and at the same time made a contract with the Société Electrique Edison de Paris for a term of five years, in which both companies would jointly contract all business in Roumania. M. Steréadi, of the Theatre National, has also been very active in pushing the matter forward.

Machine Room.

The machine room was originally intended to be placed in a large and long cellar in front of the theatre. All plans were accordingly made for this purpose. The Municipal Council of the City, however, made an objection, and it was agreed to build a small house adjoining the theatre. The machine room is built just behind a large wall, forming a terrace, this being on a level with "Calca Victoria," thus shielding its view from the principal thoroughfare. It covers an area of 171·6 square metres, which is divided as follows :—

Machine room	66·4
Boiler room, reservoir, well, &c.	71·9
Magazine	14·6
Office	18·7
Total in square metres	171·6

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Fig. 2 shows the front view of the machine room, together with the base of the chimney.

In the machine room, which is divided into two sections, are two high speed engines. The first section holds an Armington and Sims engine, driving two Edison machines, each capable of giving 400 16-candle lamps. The dynamo machines are of the new model, and connected in multiple arc, having their field regulated by one of the regulators. Fig. 3 is a sectional view of the whole house. Section 2 has also two dynamos of the same model, driven by a Porter-Allen engine. The connections are made in the same manner as those of Section 1, the current from all the machines entering the conductor on a switch-board placed just above the two regulators that regulate the field of both sections. This switch board consists of four large plug switches, which also make connection with lead plates or safety catches. Each pole of both sections 1 and 2 has a lead plate, and from this switch-board any one of the two sections can be cut out or put into circuit as desired. Besides this, each single machine can be cut out or put into circuit by means of switches accompanying each machine. Thus each machine, each section, or all together, are under perfect control. The field magnets of each section are connected in multiple arc, each machine having also a switch for its field circuit. In fact everything is done to insure a good working installation. Arranged upon the switch-board are two volt-meters and two ampere-meters, by which the electromotive force and current can be constantly tested. The volt-meters are connected between the poles of each section, and in order to see the current, it is only necessary to pull out the plug of that particular switch at the extremities of which the wires of the ampere-meters are connected. The current, being too strong to go direct through the instruments, is shunted through coils, the resistance of which is exactly known. Fig. 4 shows the

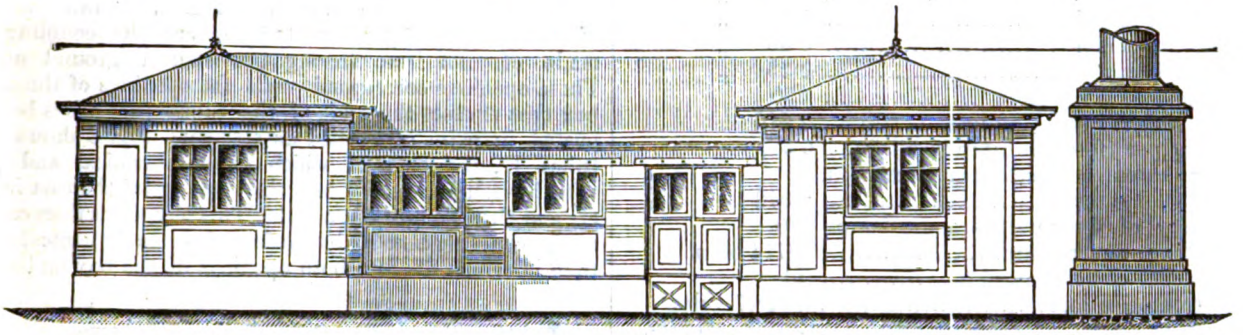

Fig. 2.—Machine Room.

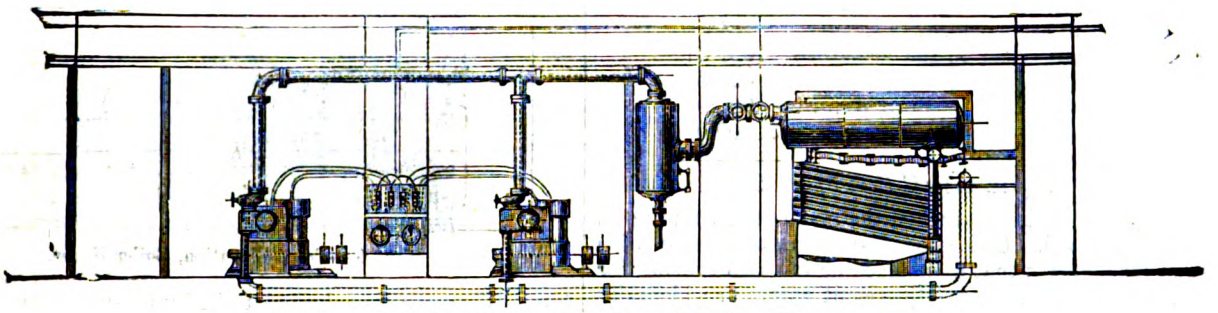

Fig. 3.—Sectional Elevation of Machine Room.

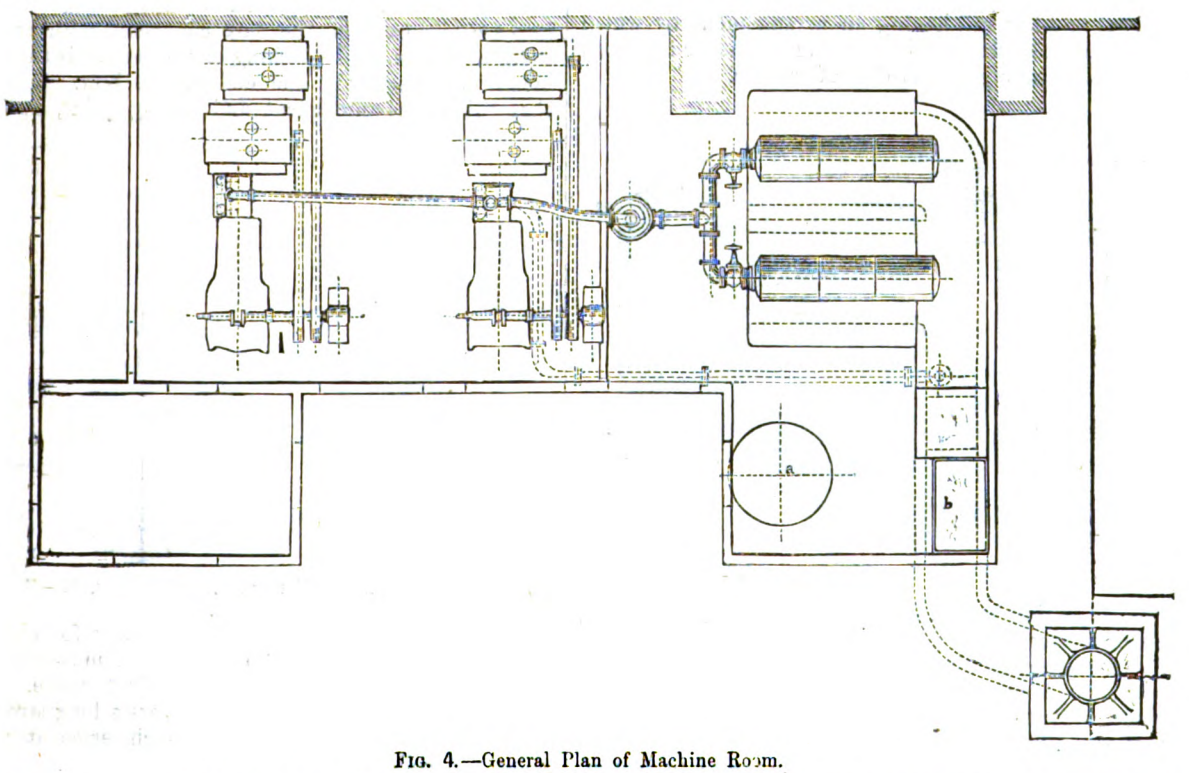

Fig. 4.—General Plan of Machine Room.

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general disposition of the engine, dynamo machines, boilers, &c. It will be seen from this plan that the installation is very compact, regarding the number of lights that can be supplied from it. The new model of the Edison dynamo machine is claimed to be one of the most perfect, simple, and cheapest machines per lamp in the market to-day. The following are the dimensions and qualities of the machines installed at Bucharest:—

Base, length	1·75 metre.
„ breadth	0·96 „
Height of machine	1·41 „
Pulley, diameter	0·40 „
„ breadth	0·23 „
Revolutions per minute	950
Total weight in kilogrammes	2,610
Weight per 16-candle lamp in kilog	6·5
Floor space occupied per lamp in square metres	·0042
Capacity of dynamo, 16-candle lamps	400
Resistance of armature	·0114 ohm.
Resistance of field magnets	14 „
Electromotive force	112·47 volts.
Current	304·5 amperes.
Current absorbed in the field magnets when in circuit with a part of the regulator, in amperes	4·5
Voltamperes absorbed in the armature	1057·01
„ „ „ field magnets	490·5
„ „ „ lines, &c.	900·0
„ „ „ lamps	31800·0

V (112·47) × C (304·5) = 34247·51 voltamps

The above data holds good when the machine is running at its full power or load. One good feature in connection with the Edison machines is that each machine has two brushes for each pole, thus admitting easy adjustment without accidentally interrupting the circuit when the machine is running. Each machine is also placed upon four rails bolted upon a wooden frame, the first and last rail having an arrangement by which the machine can be shifted whilst running whenever the belts become slack, thus saving a good deal of trouble.

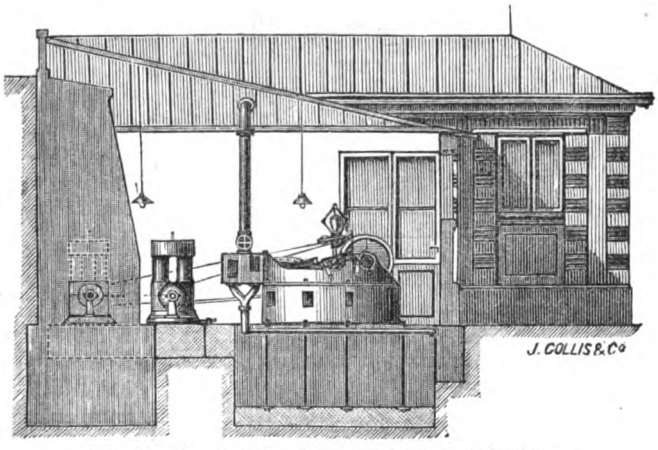

FIG. 5.—Porter-Allen Engine driving two Dynamos.

Fig. 5 shows section 2, with the Porter-Allen engine driving the two dynamo machines.

Fig. 11 is a theoretical diagram of the dynamo machine and switch-board, the heavy lines indicating the main cables from each machine, while the dotted lines represent the field circuit and connections. Fig. 10 shows one of the main plug switches and safety cut-outs combined. Fig. 9 shows the plate of lead connected between the two thumb screws of the plug switch.

Boiler House.

The boilers are two of the multitubular inexplosive boilers (system, De Naeyer and Co., of Willebroeck, Belgium). Each boiler has a capacity of 80 *force de chevaux*. Each boiler has 96 wrought iron tubes, the tubes being 4 metres long, and placed vertically in a series of eight rows, each row having 12 parallel tubes. These tubes are laid inclining towards the back and divided into compartments, so as to utilise as much as possible the heat generated below. Each boiler contains 144 square metres of heating surface. These tubes, in which the steam is generated, are connected together by coupling pieces of great simplicity and strength. The weak points in tubular boilers are the joints, which if not properly connected cause a great deal of trouble. The coupling pieces of De Naeyer, however, obviate some of the defects. They form a perfect joint and of such strength that when once connected they seldom give rise to trouble. Fig. 7 shows three pairs of tubes, vertically connected. a' are the coupling boxes, made of cast iron, having two conical ground openings. These openings correspond with the openings of the cast iron box that encases the ends of the tubes (the tubes being connected in pairs, and called an element). Fig. 8 shows the two tubes B′, the ends of which are also conical and pressed with hydraulic pressure into the openings of the cast iron box, C′, and then flanged out a little. This box, C′, is then connected to the coupling box a' by means of a small conical piece of tube D′ which fits into both openings of the box and coupling

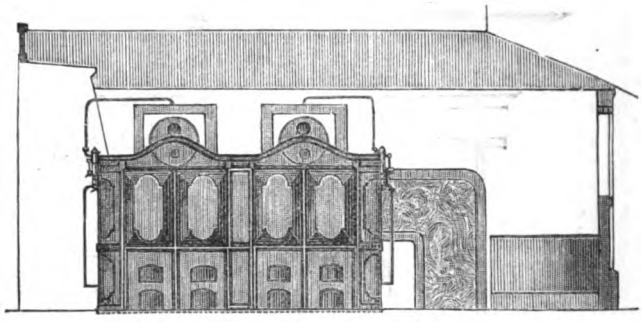

FIG. 6.—Front Elevation, Boiler House.

box. They are then locked tight by means of an iron cross piece, E′, the arms of which press into recesses made in all coupling pieces. The bolt F′ of this arm piece is introduced into a cavity cast in the box connected with the tubes, and there held firm. The locking or tightening is then effected by means of the screw at the end of the bolt. It will be seen that this forms an efficient and strong joint, and also admits

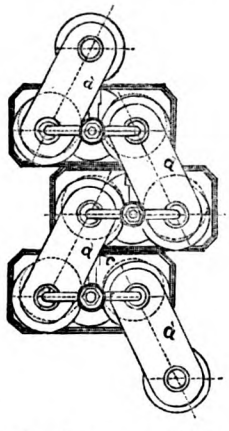

FIG. 7.—Connection of Boiler Tubes.

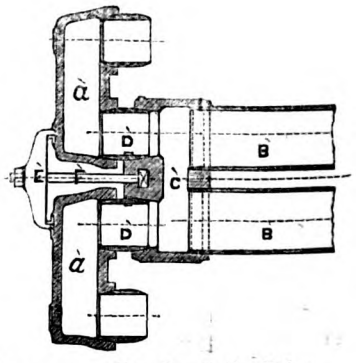

FIG. 8.—Boiler Tubes.

of easily taking apart whenever necessary for cleaning. The grate bars occupy about 3·5 metres. The steam room is 4·5 metres long, and has a diameter of 0·9 metre. The steam coming from the series of tubes enters a long strong iron box called the collector, that connects each series at their highest point. A collector resembling this one is also placed at their lowest point, making a second connection. At one of the extremities of this last-mentioned collector is attached a large faucet, used as blow-off cock. The small diameter of the tubes, considering the resistance of the iron, which is tested at 40 atmospheres, renders them almost inexplosive. Should, however, an accident through some gross carelessness occur, the result would be nothing more than the tearing of one of these tubes, without sending broadcast any fragments.

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Fig. 6 represents the front view of the boiler house, and shows the canal leading from the boilers to the chimney.

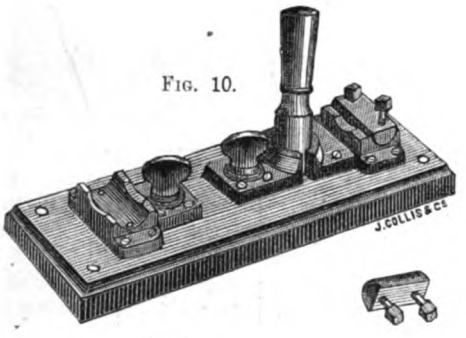
Installation inside the Theatre.

The cable leading from the main switch-board in the machine house passes to the second floor underneath the stage, and from there in a vertical direction upward to the third box or stall on the stage.

There are two objects of interest in this box—first, the grand switch-board of safety catches or plugs, and second, the regulator for the stage lights and auditorium. From this switch-board run all the principal lines carried throughout the theatre. Each of these lines has also its auxiliary cut-outs—in fact every branch, no matter if containing one or more lamps, has a cut-out with safety plugs on each pole. Table 1 shows the number of main lines, with their respective number of lamps, that run from this switch-board. The lines are all well insulated, and laid in wooden mouldings. The whole system was tested with the earth by means of a

Fig. 9.

Fig. 10.



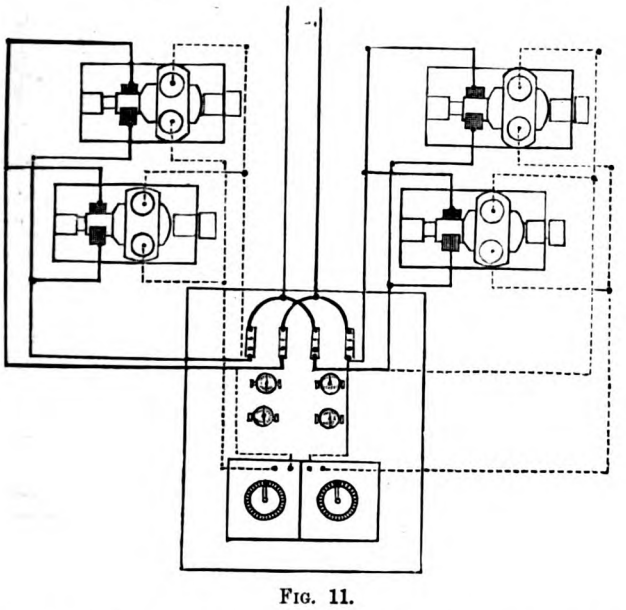


Fig. 11.

Thomson reflecting galvanometer and Wheatstone bridge, and gave a resistance of about 40,000 ohms. This is very good, considering that there are 1,921 branches.

The lamps used here are the Edison 1·08 carcel (10 candle) ones. They require 106 volts, and have a resistance at 1·08 carcels of 230·3 ohms, thus taking 0·46 ampere. The amount of copper used in conductors is about one-fourth of that used by other companies whose lamps have a resistance generally from 50 to 60 ohms hot. Table No. 2, which was made at the laboratory of the Société Electrique Edison at Ivry-sur-Seine, shows the different electromotive force, current and resistance of these lamps at various candle-powers.

Regulator.

The regulator, which is about 1·75 metre high, and two metres broad, consists of 13 switch-boards that are connected with the resistance coils, and 12 switches that serve to make connection with different lines, by means of which these lines can be connected with the regulator switches, and thus put more or less current on that line. Fig. 12 shows the regulator complete, with the lines running from it. There are 40 wires entering it, which connect and operate all lamps on the stage and auditorium (coloured lamps included). Then there are 13 cables, 10 of which each contain 20 well insulated wires that lead to the resistance coils, and which divide the coils into small detachments, thus admitting a gradual increase or diminution of resistance, which regulates the intensity of the light in that particular circuit. The other three cables each contain 30 wires serving the same purpose. The

Table No. 1.

Circuit No.	No. of lamps in the circuit.	White lamps.	Red lamps.	Green lamps.	Circuit leading to the		
1	78	26	26	26	Cross lights.	Stage lights.	Lights under the control of the regulator.
2	78	26	26	26			
3	78	26	26	26			
4	78	26	26	26			
5	78	26	26	26			
6	78	26	26	26			
7	84	28	28	28	Foot-lights.		
8	84	28	28	28			
9	16	16	...	...	Portable lamps.		
10	36	36	...	...	Side lamps.		
11	80	80	...	...	1st etage Royal circuit.	Auditorium.	
12	134	134	...	...	1st etage ordinary circuit.		
13	80	80	...	...	2nd etage Royal circuit.		
14	80	80	...	...	2nd etage ordinary circuit.		
15	50	50	...	...	3rd etage Royal circuit.		
16	60	60	...	..	3rd etage ordinary circuit.		
17	70	70	...	...	Large chandelier Royal circuit.		
18	103	103	...	...	Large chandelier ordinary circuit.		
19	28	28	...	...	Royal apartments.		
20	26	26	...	...	Orchestra.		
21	33	33	...	...	Dressing room right.		
22	102	102	...	...	Dressing room, centre and left.		
23	55	55	...	...	Above and below the stage.		
24	67	67	...	...	Chandeliers in the large and small foyer.		
25	89	89	...	...	Large foyer.		
26	42	42	...	...	Small foyer.		
27	122	122	...	...	Vestibule.		
28	12	12	...	...	Machine house.		
...	1,921	...	...	...	Total number installed.		

Table No. 2.

Candle-power.	Electromotive Force.	Current.	Resistance
0	—	—	305
1	76	·2878	264
2	82·5	·3286	251
3	87	·3565	244
4	92	·3833	240
5	95	·4008	237
6	98	·4170	235
7	100	·4291	233
8	102	·4415	231
9	104	·4511	230·5
10	106	·4602	230·3
12	108	·4695	230

regulator is situated in a box or stall on the stage, thus affording the person operating it a good view of the stage and auditorium. This regulator differs from the one that is installed in the Brünn Theatre, inasmuch as the one in that theatre is operated on a sort of iron counter or table, while the one here is upright, takes less space, and can be easily detached. Switch I., in Fig. 12, leads to the portable stands, which can be placed and operated from twelve different

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points on the stage. These portable stands consist of a large reflector, before which is placed a battery of lamps. These lamps make their connection by means of a flexible cable leading from underneath the stage. This reflector is placed upon a stand capable of being turned in any position, and is generally used to throw a flood of light in one direction to give a more marked appearance to a certain person or thing. Switch II. leads to the side uprights, of which there are twelve pieces, or rows, each containing three lamps. Switches III. and IV. lead to the footlights. These lights are divided into two sections, the right and the left. Both these sections contain three different lines, one for the red lamps, one for the green, and one for the white. The lines are connected with the resistance coils by means of this switch, which, when pushed on the first button gives white lamps, on the second red, and on the third green. The fourth button is blank, and when pushed on, this button interrupts or breaks the line suddenly, which makes the appearance of lightning. Switches V. to X. lead and control the whole of the six crosslights.

Each of these crosslights also contains three different circuits, for white, red and green lamps. Switches XI. and XII. serve to connect and break the royal and ordinary circuits of the auditorium. It may be mentioned that all circuits in the theatre are run in such a manner that there is the same electromotive force at all points of the line—that is, between the first and last lamps on each line there is no fall of E.M.F., and may be regarded as if all lamps were connected and bunched at one point. All the switches that are connected with the resistance coils I.′, II.′, III.′., and so on to X.′, make connection with the switches above; for instance, resistance switch I′ has its connection with switch I. that puts the line in its circuit II.′ with II., and so on.

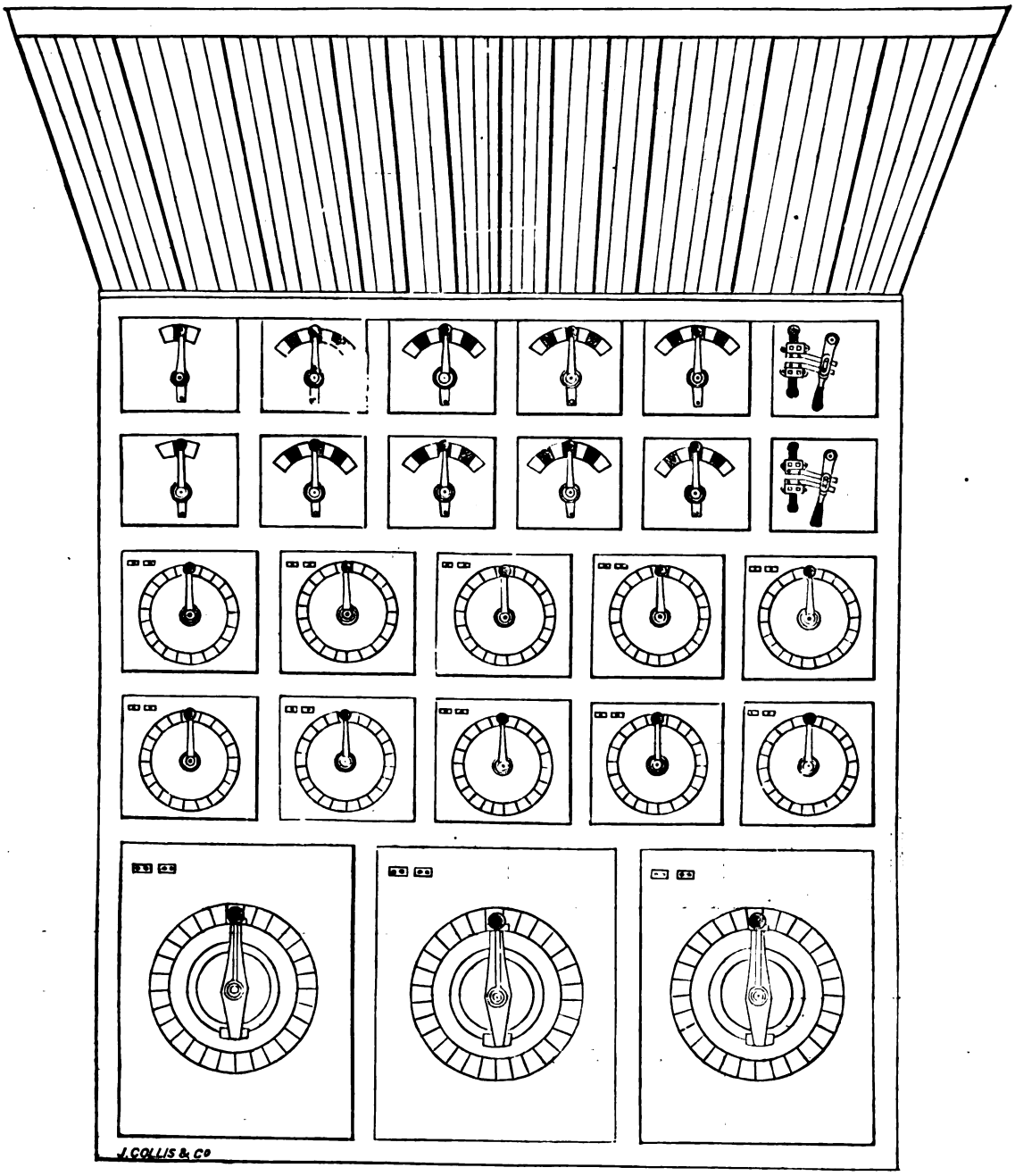

Fig. 12.—Regulator.

XI.′ and XII. control the two auditorium lines, while XIII. controls all the stage lines at one time. Thus each particular line can be regulated, or all together, at will.

There is no doubt that the installation here will be enlarged during the summer so as to light the new Palais Royal, which will require at present about 1,200 lamps. It may be mentioned that the International Brush Company have been doing some work there, and, as far as parliamentary usage will permit us to say, the authorities were dissatisfied with their work, and it was consequently handed over to the Société Electrique Edison.

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ON THE CALCULATION OF MAINS FOR THE DISTRIBUTION OF ELECTRICITY.*

BY W. H. SNELL, ASSOCIATE.

(Continued from page 124.)

Group II.

It will be convenient to take next Group II., omitting Group 1A for the present. We shall probably be able to assign the mean annual usage per day for the lamps in Group II with a fair degree of accuracy in most cases. These lamps, being chiefly in public buildings, will sometimes be lit at dusk, sometimes later, and in some cases earlier, according to the character and use of the building. But there will rarely be more than one such installation upon any one section of the cable, simply because, after supplying such an installation, we should almost invariably reduce the size of the conductor. We shall therefore content ourselves in this place with a formula adapted for finding the thermal current for one such building only.

Now, in this case the number of lamps in use may be assumed to be constant throughout the (daily) period of lighting (if this is not so, at least the great majority of the lamps will be "on" or "off" together). We shall require two sub-divisions as a general rule. For week days we will write N_3 and for Sundays N_3''. To find N_3,

Let d_3 be the number of week days per annum for which the lamps will be used.

Let the average period during which the *building* (not the lamps) is in use on each of these days be from the time α to the time ω.

Let t' be the mean annual number of hours per day from dusk up to the time ω;

and t'' the same number up to the time α.

The values of t' and t'' are given in Table I., Column C.

Then we shall have

$$N_3 = \sqrt{\left\{ \frac{d_3\, n^2\, (t' - t'')}{Q} \right\}} \quad . \quad . \quad . \quad (26)$$

TABLE I.

A.	B.	C.	A.	B.	C.
p.m.			p.m.		
4:30	36	0·098	11: 0	1787·5	4·9
5: 0	91	·249	11:30	1970	5·4
5:30	151·5	·415	12: 0	2152·5	5·9
6: 0	229	·627	a.m.		
6:30	323	·9	12:30	2335	6·4
7: 0	433	1·186	1: 0	2517·5	6·9
7:30	561	1·537	2: 0	2882·5	7·9
8: 0	704	1·93	3: 0	3247·5	8·9
8:30	875	2·4	4: 0	3603	9·87
9: 0	1057·5	2·9	5: 0	3875·5	10·617
9:30	1240	3·4	6: 0	4080·5	11·18
10: 0	1422·5	3·9	7: 0	4223·0	11·57
10:30	1605	4·4	8: 0	4300·5	11·78

Column A gives the successive half-hours from 4:30 p.m. to 8 a.m. (here we take α and ω).

„ B gives the total annual period of darkness from sunset to each half-hour.

„ C gives the values of (B ÷ 365). t' and t'' are taken from this column.

Whenever α has any constant value earlier than 4:30 p.m. we shall have $t'' = o$. (This table is only correct for the latitude of Greenwich.)

As an illustration suppose that a building lit by 100 lamps is used two nights a week all the year round from 7 p.m. to 8:30 p.m., we shall have $n = 100$, $d = 104$, $t' = 2{\cdot}4$ $t'' = 1{\cdot}186$.

$$N_3 = \sqrt{\left\{ \frac{104 \times 100^2 \times 1{\cdot}214}{8{,}766} \right\}} = \sqrt{144}$$

$$\therefore N_3 = 12.$$

*Paper read before the Society of Telegraph-Engineers and Electricians.

Group Ia.

Take next Group IA. This group accounts for lamps which properly belong to Group I., but whose normal hour of extinction is at 6 p.m. or earlier. Let the required thermal current correspond to N_2 lamps; then, if we reckon as before by half-hours, there will be four terms from the earliest period of dusk (in these latitudes) to 6 p.m. The value of N_2 is therefore given by

$$N_2 = \sqrt{\left\{ \frac{d_2\,(n_1^2\, t_1 + n_2^2\, t_2 + n_3^2\, t_3 + n_4^2\, t_4)}{Q} \right\}}$$

where t_1, t_2, . . . are the first numbers in column C, Table I. It will perhaps require a moment's consideration to see that if these lamps are in use on *every* day of the year on which there is darkness before 6 p.m. we must put $d_2 = 365$; if they are not used on Sundays, $d_2 = (365 - 52)$, and so on.

It is obvious that this method of calculation might be adopted for all the "Regular" lamps, but it will be seen that it would usually involve considerably more labour in working out the results, as the coefficients of the squares of n would no longer be unity, and their proper values would also vary with the latitude.

"IRREGULAR" DIVISION.

For the "Irregular" division all that can be done is to take the best available estimate of the number of lamp-hours they may be expected to make per annum, and thence obtain a value of N_4 by means of equations (8) and (10). It seems probable that, except perhaps in residential districts, N_4 will seldom be large in comparison with the other terms of N.

Daylight Work.

It may sometimes be desirable to form another value of N, to account for the whole of the work performed during the hours of daylight. We will call this N_5, but we need not stay to consider how it should be formed.

Collation of Groups.

We have now to collate these separate terms so as to find the value of the thermal current for all the lamps upon the section. For the sake of clearness at a subsequent stage we shall write this collated value S_a. S_a, S_b, ... will therefore be the number of lamps corresponding to that part of the final thermal current in each section *which is proper to the lamps supplied directly from that section.*

Definition of "Final Thermal Current."

We reserve the term "*final* thermal current" to indicate the ultimate value of $C\varrho$, which includes the current transmitted through the particular section to sections beyond. We will afterwards show more in detail how this may be estimated in a system of conductors. The number of lamps corresponding to this final thermal current will be written ϕ_1, ϕ_2, ...

We will here collect the various terms of N for convenience of reference:—

Division (1)—"Regular" lamps—

Group I.—Lamps lit at dusk	... ...	N_1
„ I'. „	for Saturday work only...	N_1'
„ I''. „	for Sunday work only ...	N_1''
„ Ia. „	not in use after 6 p.m....	N_2
„ II. „	in public buildings (chiefly)	N_3
„ II''. „	„ for Sunday work only	N_3''

Division (2)—"Irregular" lamps ... ... N_4

„ "Daylight" work ... ... N_5

This list has a somewhat inconsequent air, but after what has been already said it will not be necessary to add any further explanation of the *raison d'être* for this classification. It is obvious that the scheme is very elastic, and that, as we have attempted to deal with the most general case, it may often be simplified in actual use.

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To find S_a it will be necessary to deal with these terms successively, for it is obvious that they do not all require the same method of collation. It will be seen that the following is probably the best order :—

(1)	Combine	N_1	with	N_1'	; call the result	N_a
(2)	,,	N_a	,,	N_2	,,	N_b
(3)	,,	N_b	,,	N_3	,,	N_c
(4)	,,	N_1''	,,	N_3''	,,	N_d
(5)	,,	N_c	,,	N_d	,,	N_e
(6)	,,	N_e	,,	N_4	,,	N_f
(7)	,,	N_f	,,	N_5	,,	S_a

We have for the fundamental formula (*vide* Equation 14 *passim*)—

$$N_{(x+y)} = \sqrt{(N_x^2 + N_y^2 + A} \quad . \quad . \quad . \quad . \quad . \quad (14)$$

where $$A = \frac{2}{T}(n_1 m_1 + n_2 m_2 + \quad . \quad . \quad .).$$

(To be continued.)

SELF-MESMERISM OR SELF-HEALING.

A Mr. Harvey sends us some remarks on this subject. Amongst many other things, he says :—"All that the self-mesmerist or self-healer has to do is to sit down quietly, close the eyes, and turn his consciousness or mind everywhere within his body, probing, searching, and examining, so as to become as it were conscious of all the processes of the body, which are otherwise automatic or unconscious. Daily self-introspection and vigilance are needed. In this way through the nerves, through the circulation, and through the muscles, the self-healer forces physical force to flow as heat and muscular energy. "There should," says Mr. Harvey, " be several hospitals for self-mesmerism or self-healing." Now, if we can arrive at this desirable end whilst sitting upon our own particular doorstep, why want hospitals? If the people who threaten us with apoplexy by sending us stuff of this sort would turn their consciousness, self-introspection, vigilance, or whatever it may be, into *our* bodies, they would discover a degree of irascibility, heat, and muscular energy which might produce a decided effect could distance be annihilated.

ON ELECTRIC TRAM CARS.*

BY A. RECKENZAUN.

It may be premature to read a paper on the subject of electric tram cars, considering that at this moment there is only one such car in existence in this country, as far as the author is aware ; this solitary example, moreover, has only been in operation experimentally since October last, therefore the invitation of the council of this institute was accepted with a considerable amount of hesitation. The Inventors' Institute has a privilege before other societies in this respect, that it will judge of the merits of an invention as an invention apart from the commercial aspect of the problem. Utility, however, is the first desideratum in an invention, and the author now submits to this institute the first question of utility. Before going into the details of our subject it may be interesting to dwell for a moment upon the figures in this table, which was prepared in order to show what power a pair of horses are capable of exerting.

Power exerted by two horses in pulling a car with passengers, weighing 4½ tons, tractive force 30lb. per ton :—

At 7 miles per hour on level road			2·52	horse-power.
,, 6 ,, ,,	,,	.....	2·16	,,
,, 6 ,, ,,	gradient	1 in 75.....	4·32	,,
,, 5 ,, ,,	,,	1 in 37.....	5·4	,,
,, 4 ,, ,,	,,	1 in 37.....	4·32	,,
,, 3 ,, ,,	,,	1 in 25.....	4·32	,,
,, 4 ,, ,,	,,	1 in 25.....	5·76	,,
,, 5 ,, ,,	,,	1 in 25.....	7·2	,,
,, 3 ,, ,,	,,	1 in 18.....	5·4	,,

The additional power necessary to pull a car round curves cannot be ascertained with the same accuracy. It depends upon the radius of the curve, the amount of play in the axle boxes, and the size of the wheel flanges. A flexible wheel base will considerably facilitate the movement on curved roads, and wet rails offer less resistance than dry ones. The force required to start a car and to get up speed is necessarily greater than the force required to maintain the speed uniformly. It is a variable quantity, says Mr. D. K. Clark in his admirable book on tramways, for it may be anything that horses choose to exert. But it has been found by experiment that the momentary starting force is about four times the tractive force when once in motion ; thus we may form a rough idea as to the exertion of a horse in starting a car on the level or on an incline. Horses cannot tell us of their sufferings, we know merely that their life in tramway service is short, although they do not work longer than 3 to 4 hours a day. It seems barbarous to use horses as these figures show ; still, there has been no economical substitute until recently, and it is only within the last few years that mechanical traction has made any headway. That mechanical power will supersede animal power, and that at no distant date, is admitted on all hands, and the question of the kind of mechanical power to be employed is still an open one. It is often asked why so much mechanical power is required for the propulsion of tram cars, and why it is necessary that a tramway locomotive should be made to give as much as 40 indicated horse-power, whilst 2 horses seem to do the same amount of work. The above table shows what mechanical work is actually being done. James Watt ascertained experimentally that a strong dray horse was capable of producing a continuous effect of 33,000 foot pounds per minute, but we see that one tram horse does the work of three dray horses very frequently. When we now consider that a tramway steam locomotive weighs from eight to ten tons without the car and passengers, it becomes evident that the indicated horse-power just given is no extravagant measure. Take a locomotive engine, car and passengers, weighing together fourteen tons ; in order to move that load on a level road with 30lb. tractive force per ton and at a speed of seven miles an hour we require between seven and eight actual horse-power, which is equivalent, after allowing for engine friction, to about eleven indicated horse-power, and in travelling up an incline of 1 in 37 this power will amount to something like thirty-four indicated horse-power. Reducing our figures to a coefficient and maintaining that the tractive force is 30lb. per ton on a level but dirty road, we come to the conclusion that when moving at the rate of seven miles per hour on a straight line we consume in round numbers eight foot pounds of work per minute for every pound weight on the rails, on an incline of 1 in 75 we consume sixteen foot pounds, and on an incline of 1 in 37 twenty-four foot pounds for every pound weight carried at the same speed. Therefore it is of the utmost importance to reduce the dead weight to be propelled to a minimum. Where a locomotive engine has to drag the car behind it it becomes necessary to provide weight in order to obtain good adhesion on the rails, and the best plan no doubt would be to utilise the weight of the car and passengers to furnish the requisite adhesion. The number of steam locomotives employed in tramways is daily increasing, and steam traction is gaining in public favour. It is not within the range of this paper to examine into the advantages or disadvantages of steam traction, but merely to show whether electric cars have any chance of success from a utilitarian point of view. We distinguish between the terms electric car and electric tramway or railway ; the electric car carries its energy within, and it is quite independent of external influences, whereas with electric tramways the energy (electricity) is conveyed from the generating station to the rails or other conductors communicating with the motor which turns the car wheels. Separate conductors are used by Messrs. Siemens and Traill at Giant's Causeway and elsewhere. Mr. Magnus Volk, at Brighton, conveys the current through the rails. The nature of the ground on the Brighton beach does not allow of any accumulation of wet and dirt, the rails are above the level, and there is no traffic across the line. An electric tramway is now being constructed at Blackpool, where the current of electricity is to be conveyed through conductors in a pipe laid underground. This pipe has a slot throughout the whole length to permit of the connection between the car motor and the conductor beneath the surface of the road. Our electric tram car requires no conducting medium. It does not interfere with the rails or roadway, nor with other traffic, it can be readily shifted from one line to another of the same gauge, and it can be run in conjunction with the horse cars.

The Battery.—The first requisite for an electric car is a battery, which can be stowed away within the car. Such battery has to be of small weight, it must be reliable, supply any quantity of current according to the requirements of the road, and it must be cheaper to maintain than horseflesh, and emit no smell. Primary batteries were out of the question ; the cost of zinc and acids consumed in them would be much greater than the cost of animal power, independent of the difficulties attending the process of refilling such batteries when exhausted. The invention of the secondary or storage battery put the question entirely in a new light. Certain successful laboratory experiments at once suggested the adaptability of this invention to the propulsion of vehicles. Four years have elapsed since the introduction of the Faure accumulator into this country ; it caused quite a sensation at that time, and money could be found in abundance for the exploitation of anything that bore an electrical name. Things have changed entirely since then. The original Faure battery has never been of any practical service, and very substantial improvements had to be made, at enormous costs, to bring the secondary battery to a commercial value. The Electrical Power Storage Company have acquired the patent rights of M. Faure, in addition to those of Messrs. Sellon, Swan, and Volckmar, and they have step by step improved the mechanical details of these secondary batteries till they arrived, after fearful labours and expenses, at what may be termed a thoroughly practical article. But the prejudices created in the public mind by early failures have not quite worn off yet, and it will require something wonderful and startling to convince the public that the work of the last four years has produced remarkable improvements. None but those who have been intimately connected with the manufac-

* Paper read at the Inventors' Institute, May 18, 1885, Mr. C. E. Spagnoletti, President of the Society of Telegraph Engineers and Electricians, in the chair.

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ture of storage batteries can form an idea as to the numerous difficulties which had to be surmounted before a permanent success was obtained. The battery was long ago perfect from a theoretical point of view, but it could not stand the test of time. Time was an essential factor; it took many months to test the durability of a set of cells, and it was only by close observation and careful remedying of defects one by one as they appeared that the storage battery assumed its present form, simple as it may appear to the uninitiated. The cell before you is one of a set of the type specially designed for tram car work. In a lead-lined strong teak box are placed 21 lead plates, weighing together 26lbs., inclusive of connecting strips and terminals; ten of these are called positive and 11 negative. Each plate is formed of a lead grid, the perforations of which are filled with a paste of lead oxide; the positive plates contain thin red lead, which in charging is converted into peroxide, and the negative grids are filled with a paste of litharge, which in charging is reduced to spongy lead capable of absorbing hydrogen. We store, therefore, not electricity, but oxygen and hydrogen, which gases, by discharging the battery, manifest themselves externally in the form of electrical energy. This box is filled with sulphuric acid and water at a specific gravity of about 1,150 deg.; then a lid is put on, sealed all round the edges to prevent any spilling of acid. This acid is never removed so long as the battery lasts. There is no reduction of lead or any material going on within the cell, and the battery would last for ever but for the fact that the lead grid of the positive plates becomes so brittle with oxidation that it crumbles to pieces in the course of time; then these positive plates have to be replaced periodically by new ones, but the old lead is valuable. The life of a positive plate depends entirely upon the amount of work it has done. The plates in the box before you have been at work since September last year, and they are still in excellent condition, I should say they are still as good as new; they have frequently been discharged at the rate of 100 amperes, whilst the average working current is 46 amperes. These cells are always being charged at the rate of 32 amperes, and the storage capacity of a cell is 150 ampere hours. Sixty such cells will weigh 1¼ ton, and propel a car with 46 passengers for about 2 hours over a road with ordinary inclines, curves, and 60 stoppages per hour. The diagram represents a car which has been running at Millwall and at Battersea. The accumulators are placed on trays under the seats, out of sight. These trays can be drawn out through doors at one end of the car, and replaced speedily. A trolly containing a fresh set on trays and rollers is drawn up to the end of the car. The discharged cells are pulled out all together by means of a small winch, and the newly-charged ones pushed in, when the car is ready to proceed on its journey. There are three sets of accumulators to each car—two sets charging whilst one set propels the vehicle; thereby time is saved and waiting prevented.

The Electro-motor.—This machine has to convert the electric current into mechanical power. For tram car propulsion it is absolutely necessary that the motor should have a high efficiency, and at the same time be of small dimensions and little weight. To combine these requirements has been the aim of the author, and he has at length produced a machine (shown on the diagram), which has had some rough tests in actual service under the most trying circumstances and conditions. There are two motors driving the car, each capable of working up to nearly 9 horse power, and weighing 420lbs. Each motor is supported independently upon a small bogie, the whole mechanism is self-contained, and each separate bogie forms a small locomotive engine upon which the car rests. One axle of each bogie is a driving axle; thus we obtain four small driving wheels, which give the requisite grip upon the rails. Either bogie can be detached from the car in less than one hour, so that in case of repairs and inspection the motor can be taken out and replaced without letting the whole car stand stand idle for any length of time.

The Gearing.—The speed of the motors is necessarily high—about 1,000 revolutions when the car runs at seven miles per hour; thus it is necessary to introduce some mechanical reducing gear between the motor shaft and the driving axle. The gearing employed consists of a worm on each motor shaft, and worm wheels on the driving axles, giving a ratio of about 1 in 12. The worm gearing is boxed in, likewise the motor, and the wheels run in oil; dirt is thereby excluded, and the lubrication perfect. Easy access is obtained to the motors and lubricators through doors in the floor of the car.

Variation of Speed and Power.—This is obtained by means of a compound switch, which arranges the motor circuits, so that the machines shall work in series, in parallel, or singly. Thus, the resistance of the circuit being varied, the power and the speed vary accordingly. When a greater range of speed is desirable, the motor circuits are still further divided by arranging the field magnet wires apart from the armatures. This obviates cumbersome gearing, which would add to the weight and expense, increase first cost, as well as maintenance. The driver has full command over the motive power; one handle suffices for all the operations of starting, stopping, and varying the speed or power. There is no useless electrical resistance, and therefore no waste of energy, whatever speed the car may be travelling at. The car is provided with these details at both ends, so that the driver has merely to remove the handles and two connections at the end of a journey, and then proceed. It would be an easy matter to vary the speed by decreasing or increasing the number of cells, and thereby vary the electromotive force. This method, however, is injurious to the accumulators, because some of the cells would be discharged sooner than the others, and when they are all recharged in series, some would have to be very much overcharged before the rest could receive their share. There would not only be a waste of power occasioned by the evolution of gases for no purpose, but the life of the cells and their efficiency are reduced by this irregular treatment.

Brake Power.—At each platform there is the usual vertical shaft and brake handle. A chain is wound upon this shaft when the handle is turned and eight brake blocks are simultaneously pressed against the corresponding number of wheels. The car can be stopped in an instant. Besides this there is an electrical brake, so that the motors act as dynamos driven by the momentum of the car, or running down an incline; the whole of the power stored up in the momentum of the car is converted into electricity, and the current generated is utilised in magnetising the brake blocks, thereby increasing their grip upon the wheel tyres. Arrangements are being made to render this electric brake automatic, so that the main circuit will be broken and the brake circuit with the motors closed automatically when the speed of the car reaches a certain maximum.

Cost of Motive Power.—It has been mentioned that the capacity of the tram car cell is 150 ampere hours. We do not exhaust them entirely, but leave a margin of about 20 per cent. in the cells, 120 ampere hours' charge being sufficient to propel the car full of passengers for two hours, or about 12 miles, over an average road with frequent stoppages. When charging 60 cells at the rate of 32 amperes for four hours, and replacing the accumulators in the car every two hours, we require steam power to the amount of about 15 indicated horse-power per car. Assuming that the car has to run 72 miles in a day, and that we are supplying several cars at the same time from one engine, the fuel consumed need not exceed 4lb. per indicated horse-power per hour. The charging takes place during 12 hours of the day only; thus 7cwt. of coal per car per day will give a consumption of about 10lb. of coal per mile. Reckoning the price of coal at 18s. per ton, the fuel per car mile would cost less than one penny. By working longer hours we could do with less engine-power, but, of course, with the same consumption of coals per car mile. The most economical steam tramway locomotives burn from 9 to 12lb. of coal per mile, or about the same as quoted for the electric car. There are two reasons for this high consumption—firstly, the steam locomotive weighs four times as much as the accumulators, electric motor, and driving gear, therefore it requires greater power for its own propulsion; and secondly, a tramway locomotive boiler and engine cannot be expected to compete with a large stationary engine and boiler as regards economy. Thus the loss arising from the conversion of steam power into electricity, and the re-conversion of electricity into mechanical power, is more than compensated for by corresponding advantages. There are instances when water power is available within a reasonable distance from the tramway depôt, and in such instances the additional economy will be apparent.

Prime Cost, Maintenance, and Depreciation.—The steam engine, boilers, dynamos and shafting, and all necessary apparatus for a charging station, to supply a dozen electric cars, including spare power, will cost £4,000; and the complete equipment of 12 two-horse cars, inclusive of ample spare gear, may be estimated at £6,000. The superintendence of machinery at the charging station will cost £1,100 per annum; fuel (at 18s. the ton), water, oil, and waste, £1,400; 10 per cent. depreciation on engines, boiler, and dynamos, £400; and with an estimated depreciation of 35 per cent. on the whole propelling apparatus, we get a total expenditure of £5,000 per annum, which is equivalent to 3·5 pence per car mile run. You will observe that these figures are thoroughly reasonable, and allow of a good margin. We should have to almost annihilate the whole concern at the end of a year in order to bring the working costs to an amount allowed by some tramway companies for horsing.

The following is a summary of the principal points in favour of this system:—

1. Economy in running cost.
2. The electric car has the same appearance as those in general use, and any ordinary car can be readily converted.
3. The wearing parts of the mechanism driving the wheels are few in number and easily replaced.
4. The weight of the motive power is less than two tons, distributed over two small bogies.
5. The propelling apparatus is invisible to the passengers, practically noiseless, clean, and free from danger.
6. One man (not necessarily skilled) can drive the car.
7. The car may be illuminated at night by the electric current, sufficiently to enable the passengers to read comfortably. The power required to maintain the electric light is so small that the cost may be neglected from the estimates, for the lamps (giving together 40 candle-power) consume only three ampere hours out of 150 given by the cells.
8. The maintenance of the permanent way (paving) must be less than in the case of tramways where horses are used, the hoofs of which follow always in the same tracks.
9. The space required for a charging station for the secondary batteries is much less than that necessary for stables for horses to do the same work.
10. The same plant which charges the storage batteries may be utilised for lighting the depôt and even buildings in the neighbourhood.

Discussion.

Professor George Forbes, F.R.S.E., gave a short and concise account of the electric railways laid down in various parts of the world within the last few years, and he considered the methods of conveying the electricity through rails or other conductors clumsy and unsatisfactory. In Mr. Reckenzaun's tram cars they had no stationary engine connected with it by a conductor, and this he considered, other things being equal, a very great advantage. After the experiments made by M. Philippart with tram cars propelled by a Faure battery, he was glad to hear Mr. Reckenzaun say that storage batteries had at last been made commercially useful and practical. He now believed the difficulties which had encountered secondary battery makers in the past had been surmounted, and that the method of constructing them had been so enormously improved, that those who used them were now masters of the situation, instead of *vice versâ*. Pointing to the battery exhibited on the table, the speaker said every one was struck with its light weight, which was brought about by its being made of thin plates, thus giving a large surface and a greater current than had ever

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PRIMER OF ELECTRICITY, No. 28.

SUBMARINE TELEGRAPH CABLES: THE INSULATION TEST.

(Copyright, 1885. By A. E. BAINES.)

The following is presented to our Readers as a specimen of the Primers of Electricity published at "The Electrician" Office, price 1s., post free 1s. 3d.; in boards 1s. 6d., post free, 1s. 9d. The book will be found of great assistance to young Electricians, and has already been received with much favour by the English and American public. The Second Edition is now ready:—

THE non-conducting materials commonly employed for the purpose of insulating the copper strand of a submarine telegraph cable, or, in other words, to prevent the dissipation of the electric current into the water, are india rubber and gutta percha, or amalgams of which one of these bodies forms a constituent part. Theoretically speaking, neither are absolute *non-conductors*, but their conducting power is so low that it may, in comparison with the high conductivity of metals, be considered, for all practical uses, as non-existent. India rubber is an excellent insulator, is plastic, and as such is peculiarly suitable for office leads, &c., but it possesses several disadvantages which somewhat restrict its use. Unlike gutta percha, which improves with prolonged submersion, it has a tendency to deteriorate under certain circumstances, into which I need not at present enter, and it is therefore inferior to gutta percha for the object we have in view. In the following remarks, whenever reference is made to the dielectric or insulating portion of the cable, that reference will be to gutta percha. In Primer No. 26, on the constant of the astatic galvanometer, we have seen, from the example given in that paper, the resistance in ohms represented by a deflection of one degree of arc, *i.e.*, by one division of the galvanometer scale. That resistance was 50,000,000 ohms. In this test the conditions will be the same as those for the constant, with the exception that the unknown insulation resistance (x) of the cable is here substituted for the known artificial resistance (R) of 100,000 ohms, and an earth is used on the battery instead of a return wire as before.

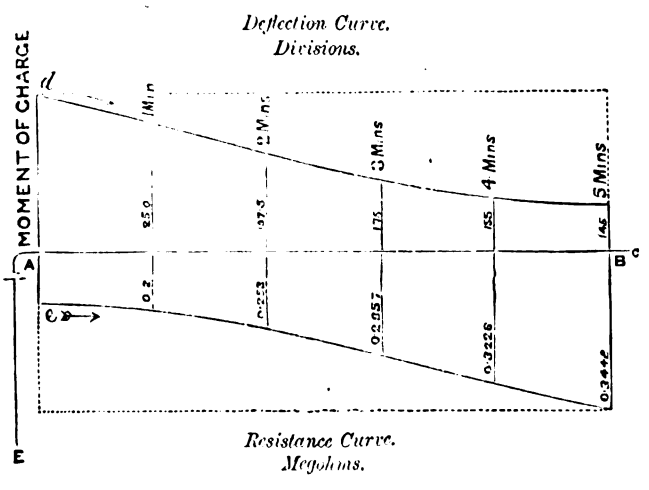

FIG. 1.

Having the above diagram in view, let the base line c be the length, 1,000 miles of a submarine cable—extending between two stations, A and B—whose insulation resistance it is required to measure. The curve d shows the process of electrification of the cable, indicated by the readings at the end of each minute, while the curve e gives the gradual increase of resistance at the end of each similar period; the ordinates in each case being in accordance with the example given below.

We shall suppose the current to be applied at the testing station A, the other end of the cable, at B, being freed or insulated, as by suspension in the air. The practical connections at A, together with instructions for taking the test, are given in Fig. 2. One pole of the battery is put to earth, a lever of the testing key a (Fig. 2) is depressed, and the circuit completed by the imperfect insulation of the gutta percha covering of the cable, which allows a certain portion of the current to escape to earth throughout its whole length. We will now presume that, after having allowed the usual 20 seconds interval between charge and observation to elapse, the galvanometer has been put into circuit by opening the short circuit key b (Fig. 2), and we are prepared to read the deflections registered on the scale of the galvanometer at the end of every consecutive fifteen seconds during a period of five

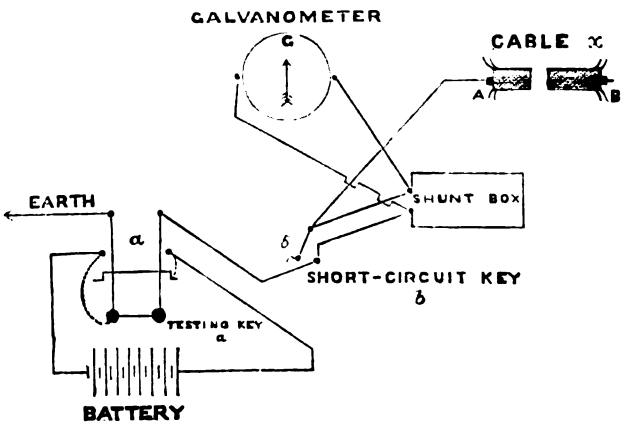

FIG. 2.

INSTRUCTIONS.—Close short-circuit key b, so as not to injure the galvanometer by the sudden rush of the current into the cable; put on current, by depressing one lever of the testing key a at any 60″; allow about 20″ to elapse, then put galvanometer in circuit by opening b, gradually.

NOTE.—This latter is best done by tapping the key until the deflection is fairly steady.

minutes. A gradual fall in these deflections will be observed (Fig. 1) until the cable has received its full charge, when the registration will remain comparatively steady. This is due in a great measure to the porosity of the gutta percha, which absorbs the current until its thousands of minute cells or pores have, in a manner of speaking, become saturated. In a short cable this process would be almost instantaneous, but in one of 1,000 miles in length the major portion of five minutes is the usual time taken up by the process of

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NOTES.

SOUTH AFRICA.—The Cape Assembly has approved the construction of an alternative telegraph cable.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ending June 30, amounted to £4,200.

THE ELECTRIC LIGHT IN VIENNA.—The Baumgarten Restaurant, near Vienna, has received an installation of Klostermann arc lamps.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 3rd inst. amounted to £2,670.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of June, 1885, were £1,333, against £1,336 in the corresponding period of last year.

THE INDIAN TELEGRAPHS.—The telegraph from Moulmein to Myawaddy, on the Siamese frontier, a distance of 75 miles, joining the Siamese line from Bangkok, will, it is believed, be finished before the coming dry season.

THE CANADIAN TELEGRAPHS.—It is stated that the Dominion Government intend to at once construct a telegraph line connecting Edmonton and Calgary, two important centres of industry in the north-west territories.

THE ELECTRIC LIGHT IN CANADA.—A successful installation of a 200-light incandescent plant has been put down in the College of Ottawa, Ottawa, Ont. This is the first educational institution in Canada to adopt the electric light.

THE EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of June amounted to £37,846, and to £37,585 in the corresponding period of 1884; increase, £261.

THE GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this company are as follow:—Receipts for June, £24,840; 1st January to 30th June, £142,840; corresponding months, 1884, £129,520; 1883, £123,480.

THE ELECTRIC LIGHTING OF A RESERVOIR.—In regard to the electric lighting of the Nottingham Park-row Reservoir, we are requested to state that the installation was put down by Oppermann Brothers, and not Oppenheim Brothers, of London.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending the 3rd inst. were £2,095, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE TELEPHONE IN MEXICO.—The Mexican Telephone Company has contracted to furnish the Government twenty-five telephones to connect the tax offices and barracks in the Federal district. Private subscribers are said to be continually increasing.

THE ELECTRIC LIGHT AND ATHLETICS.—The use of electric lights on athletic grounds has been tested for a few weeks in America, where the grounds of the Williamsburg, L.I., Athletic Club are now lighted by electric lamps. By their light games were carried out in the evening.

TELEGRAPH CONGRESS.—The head of the International Telegraph Bureau at Berne, M. Churchod, has arrived in Berlin in order to concert with the German Postmaster-General, Dr. Stephan, the final arrangements for the triennial Congress relating to International Telegraphy.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 30th June are £2,876, as compared with £3,131 in the corresponding period of 1884. The March receipts, estimated at £6,763, realised £6,875.

THE BAZIN ROTATIVE BATTERY.—The Bazin rotative bichromate battery has been designed by the inventor for the purposes of domestic lighting. We understand that M. Hospitalier is making exhaustive tests of this cell. M. Huon has, we believe, been appointed to represent M. Bazin in London, but he has no apparatus.

SIXPENNY TELEGRAMS.—The *Standard* understands that the statement of Lord John Manners, that an estimate existed in the Telegraph Department showing that a million would have to be spent during the next four years in consequence of the introduction of cheap telegrams, was a surprise to the late Postmaster-General. Mr. Shaw-Lefevre intends to make inquiries into the matter.

NEW INSULATING SUBSTANCE.—Messrs. Berthoud and Borel are preparing a new insulating substance in the following manner:—Linseed oil is maintained at a temperature of 300° until it acquires a brown colour and a sirupy consistence. A quantity of colophane is then added, and the mixture stirred for a time. To cover a body with an insulating coat it is plunged into the mixture at a temperature of 200°.

STORMS IN AUSTRIA.—A telegram from Vienna, dated the 6th inst., says that heavy masses of cloud collected above Austria Proper yesterday, and subsequently discharged themselves in torrents of hail and rain. Moravia, Lower Austria, Upper Austria, and Western Hungary in particular were sorely afflicted. At Ischl the lightning struck a villa and destroyed the brick work. At Pressburg the storm did great injury.

THE ELECTRIC LIGHTING OF STREETS.—At a recent meeting of the Commissioners of Sewers, notice of motion was given "That, having regard to the repeated failures of private companies to supply electricity, it is desirable that the Commission do undertake street lighting by electricity, and that it be referred to the Streets Committee to select a small area, and to obtain estimates of cost of installation." The consideration of the subject was adjourned.

MUSIC BY TELEPHONE.—On the 5th inst. began the regular transmission to the Antwerp Exhibition, by the Van Rysselberghe system, of the instrumental music played at the Vauxhall concert in the Brussels Park, a distance of fifty kilometres, or about thirty miles. The notabilities of the Telegraph Administration and of the Exhibition were present, and commented favourably on the clearness with which the sounds were reproduced.

LONG DISTANCE TELEPHONY.—It is stated that M. Sarrien, in addition to the arrangements already entered into with M. Van Rysselberghe, has authorised experiments to be made with the system of M. Tommasi. As a result of those experiments our contemporary, the *Bulletin Internationale des Téléphones* announces that a company is about to be formed with a capital of 125,000 francs for the purpose of exploiting the patents of M. Tommasi.

THE BENGAL TELEGRAPHS.—The Telegraph Department of Bengal is to be thoroughly reorganised. There will be only one grade of signallers, and promotion to telegraph masters will be by examination. The highest pay to be drawn by a signaller will be 150 rupees; telegraph masters of the first class will draw 250 rupees, and those of the second class 200 rupees. To encourage retirement amongst the older men employed in the department, the Government of India

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have sanctioned service from eighteen years of age being counted for pension.

THE MORAL INFLUENCE OF ELECTRICITY.—During the course of an inquiry into the profits of publicans in the West End of London it was stated in explanation of the large sum of £5 a week being paid for mineral waters, that at the time there was a telegraphic instrument behind the bar, and people wished to keep themselves as sober as they could—that they might know the betting and the winning horses. After this statement the Blue Ribbon, which is supposed to be emblematic of the Derby, should, in common fairness, be shared with the lowly and moralising Morse.

THE TELEGRAPHS AND THE WOODSTOCK ELECTION.—We are informed that no less than 600 telegrams giving the declaration of the poll were despatched from the little post office at Woodstock on Friday evening. In addition to these Press messages to the extent of over 25,000 words were sent over the telegraph wires. On this occasion the local staff was aided by members of the special telegraphic staff from London, who worked with the Wheatstone transmitter; but during the progress of the contest some 15,000 words a night were sent over on the ordinary Morse instrument by two clerks from Oxford who had been sent to the aid of the Woodstock postmaster.

TELEGRAPHIC COPYRIGHT IN INDIA.—The Legislative Department of India have circulated for the expression of public opinion the draft of a Bill giving newspapers twenty-four hours' copyright in all news and telegrams obtained at their own cost. The Bill was generally approved by the Anglo-Indian newspapers, the only objection being that in a distant country like India the period fixed was not long enough. The native press, on the other hand, which is too poor to afford special telegrams, raised an outcry against the proposal, as calculated to deprive it of the chief source of its information, namely, the telegrams published by its wealthier contemporaries.

THE ELECTRIC LIGHT AND VEGETATION. — Mr. P. P. Dehérain has concluded that the influence of the electric light on vegetation is as follows:—The electric light contains rays which are injurious to vegetation; the greater part of these rays are kept back by transparent glass; the electric light contains, on the other hand, sufficient rays useful to vegetation to maintain the life of plants entirely under its influence for two and a-half months; this amount of useful rays is, however, insufficient to bring on young germinating plants, or to bring full-grown plants to maturity. These conclusions, if we mistake not, are somewhat at variance with those arrived at by the late Sir William Siemens.

THE ELECTRIC LIGHT IN FLOUR MILLS.—Speaking of dust explosions, a case from Germany is worthy of notice. A sack of flour, falling dowstairs, opened and scattered the contents in a cloud through the lower room, where a burning gas flame set fire to the dust, causing an explosion which lifted a part of the roof of the mill, and broke almost all the windows. There can be no doubt that the majority of dust explosions are, like mine disasters, due to open lights; and as this danger can be practically avoided by the use of the incandescent electric light, there really seems to be no valid reason why it should not be introduced more generally, as those establishments which have used it express themselves in its favour.

COMPARISONS ARE——.—The *Daily News* says:—It is a fact worth recording that the message sent by Mr. Cyrus Field to the President of the United States, on Saturday evening, occupied longer in its transmission from the Buckingham Palace Hotel to Throgmorton-street than it did in its transmission from the latter station to Washington. The time taken in sending the message to Throgmorton-street was ten minutes, while the journey through the Atlantic cable and on to Washington was performed in eight minutes. It reflects credit upon the Western Union Telegraph Company that they facilitated the transmission of the messages by connecting their Cape Breton station direct with the Executive Mansion at Washington.

RETURN OF VOLUNTEERS FROM THE SOUDAN.—The detachment of the Army Postal Corps, which was selected from the 24th Middlesex (Post Office) Rifles for service in the Soudan, arrived in London on Tuesday afternoon from Suakim, and met with a very cordial reception.—Seven provincial members lately enrolled for the purpose of joining the Reserve of Trained Telegraphists, having failed to pass the medical officer, have been struck off the strength of the regiment. The commanding officer wishes that in future intending candidates for the Reserve of Trained Telegraphists will, with their application, send a certificate of health, in order that the inconvenience caused to themselves and the regiment by such cancelling of an enrolment may be avoided.

THE POST OFFICE TELEGRAPHS.—The Press Association has obtained particulars of the extensive preparations made by the Government for the new system of sixpenny telegrams. The extensions have been made on the basis of an estimate that the reduction in tariff will cause an increase of the business of the department to the extent of 30 per cent. within the first year, and the extra expenditure already incurred amounts to half a million sterling. Of this amount £475,000 has been spent in new plant—poles, wires, instruments, &c., whilst £25,000 has been laid out in the erection of new buildings. The number of female clerks at the Post Office is now being considerably increased. For every single appointment there are about a score of applicants. There have been recently 145 vacancies in the Post Office, and for these 2,500 young women applied.

BIG GUN ILLUMINATION.—On the occasion of the *conversazione* of the Society of Arts on Friday evening last, the 14-ton gun near the main entrance of the Inventions Exhibition was a source of more than usual attraction, owing to the illumination of the interior by means of a special horizontal electric arc lamp, adapted for examination purposes by Colonel Maitland, R.A., of the Royal Gun Factory, Woolwich, and manufactured by Messrs. Johnson and Phillips. A Holmes-Burke primary battery maintained the light on this occasion, the one charge of exciting fluid with which it was supplied being not only sufficient to keep the light burning brightly and steadily throughout Friday, but also on the Saturday evening, when it was again the object of universal interest. This battery also is manufactured by Messrs. Johnson and Phillips, of Charlton, Kent.

BOOKS RECEIVED.—"Volk's Electric Railway." [Brighton: Magnus Volk.] An interesting little pamphlet has been written by Mr. Magnus Volk, on the subject of the Electric Railway at Brighton. Although not a scientific exposition of the electrical transmission of power, the little *brochure* explains in a popular and simple manner how the car is propelled, and gives much information in the form of a series of answers to questions which are continually being asked by the non-scientific and perambulatory public. These answers relate to the manner in which the car is worked; how the electricity in the rails drives the car; the action of the motor; the principle of the commutator and switch in connection, with the reversal of the current and the alteration of the speed, and so on. The little work is well worth reading, and we heartily recommend it to the notice of beginners in electrical science.

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THE TELEGRAPHS BILL.—Lord John Manners is it would seem in some difficulty as to the Telegraphs Bill. He will not as a matter of probability give up free addresses, and the department cannot afford sixpenny telegrams with free addresses. The new Postmaster-General, it is understood, contends that much might be done to abridge addresses by warnings to the public and by instructions tending in the direction of brevity. But this will not avail to carry the proposal unless he can obtain the sanction of the Treasury to the prospective loss, and there, it is said, he does not meet with support from Sir Stafford Northcote or from Sir Henry Holland. According to the *Daily News*, an elaborate scheme of codification of addresses, with the object of meeting the objection (on the score of expense) to free addresses, has been brought under the notice of the Postmaster-General. If this should prove practicable, it would, says our contemporary, considerably decrease the cost of telegraphing messages.

THE EXPLOSION ON BOARD HER MAJESTY'S SHIP "VALIANT."—Some details are given of the explosion which recently occurred on the steam launch of Her Majesty's ship "Valiant," in Lough Swilly. It appears that some practice was taking place on the steam launch with what is known as a "hand charge," which in this instance consisted of 1lb. of gun cotton with some small pieces of metal, contained in a metal casing, and is used for throwing on the deck of an enemy's vessel at night. It is attached to a small detonating pistol by a light wire, the operator holding the pistol in one hand, while with the other he throws the charge. As soon as the charge lodges on the deck of the hostile vessel the pistol is discharged, and, an electric contact being made, the charge is exploded. Practice was taking place in the stern of the launch, and the operator threw the charge towards the water, but somehow the connecting wire became entangled. An effort was made to release it when the pistol went off, firing the charge. The force of the explosion was terrific.

TELEGRAMS AND CHANGE OF ADDRESS.—A correspondent of *The Times* writes as follows:—"Perhaps it is not generally known what happens when a telegram is sent to a house which the addressee (as he is called in official language) has left. As no one would be likely to guess, and as the information is important, I venture to ask you to allow me to relate my experience. A telegram from a neighbouring London district was sent to me on Friday at a house I quitted ten days ago, with these results to me and to the sender. I never received the message at all, though I am less than a mile off. The sender received a form saying that the telegram was not delivered because I was gone to my new address, which was given. The General Post Office then washed its hands of the matter, and my friend sent a servant with his message. Of course it looks as if it would have been quite as easy to post the contents of the telegram to me as to send notice to the sender of my new address, and a rather more effectual fulfilment of a contract. But this is only the aspect which the case wears to the unofficial mind."

THE PARTICULAR SERVICE SQUADRON.—A contemporary says:—"It would seem that a more perfect electric light than has yet been tried will have to be devised before a large fleet could without great risk of destruction lie at anchor for any length of time in a harbour open to an enemy's torpedo boats. The defensive boom is but a weak protection unless every yard of water can be searched by an almost continuous blaze of electric light, and that must be thrown outside the most advanced line of defence, or it becomes a danger rather than a safeguard. The 'Mercury' proved this in the fight of Monday week, when she much more frequently betrayed the movements of her own boats than succeeded in discovering what others were doing. Occasionally, however, the blinding rays from her lamp were flashed full in the face of the defenders, and that suggested how effectively a light specially contrived might be used to veil the operations of an attacking force. After long exposure to this fierce glare the eyes become so dazzled that they can see nothing for a time, and a clever foe might, in the briefest interval, manage to make a successful dash if she had thus prepared the way for it."

A NEW AMPEREMETER.—An amperemeter has been constructed by M. Heschus, consisting of a differential air-thermometer, into the two reservoirs of which are introduced the ends of wires of iron and nickel silver, soldered together. An electric current passing through these wires causes the series of solderings in one reservoir to be heated and the other series to be cooled, owing to the passage of the current being from iron to nickel silver in the one, and reversed in the other. The difference of the temperatures is accompanied by a change of atmospheric pressure in the two reservoirs, and a consequent displacement of the liquid in the manometer connecting them. Experiments made with the instruments show that Peltier's phenomenon is proportional to the strength of the current. A Grenet element gives an elongation of 4 mm. if a given unit of resistance is inserted, and with two such units 1·3 mm. Six Baudet elements give an elongation of 6 mm.; 6 elements with double the surface, 11 mm. The inventor claims advantages for his machine in its giving the intensity of the current at each moment; its cheapness, and containing no magnet to prevent its use near a dynamo; and its measurement of attenuating currents, while it may serve as a galvanometer and as a dynamometer.

THE ELECTRIC LIGHT ON THE PENNSYLVANIA RAILROAD. The Pennsylvania Railroad has been for some time experimenting with electric lighting for the purpose of introducing it permanently on its trains. For the last two months one of the regular trains between New York and Chicago has been lighted by electricity, and with eminently good results. The current is obtained from secondary batteries, which are placed under the car body. At present one of the parlour cars is supplied with eighteen of the constant current storage batteries, the total weight of which is 800 pounds. They are capable of supplying 120 ampere hours. The lamps employed are of the Bernstein type, and there are 12 lights in each car. Ten of these are 20 candle-power and two of 10 candle-power. They run at 35 volts and require 1·5 ampere for their full power. The batteries are charged at each end of the route, and are not removed from the cars. Electric leads are run to them and connection made, similar in manner to the charging of the gas reservoirs now employed. The size of each individual cell is 6″ × 9″ × 11″, so that the space occupied is very small. Several sleepers and ordinary passenger coaches are now being fitted up, the efficiency of the battery having been proved to be very high, and its construction eminently suited to the conditions under which it is used.—*Electrical World.*

HISTORY REPEATS ITSELF.—It was in 1846 that gas was introduced in Stuttgart, and a number of old women who had been employed by the Town Council to light and trim the ancient oil lamps walked in procession through the streets of the town bitterly complaining that they had been robbed of their bread and butter by the new invention. The complainants to-day are the directors of the gas companies and their shareholders. But the shouts and yells of the old lamp-

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lighters in Stuttgart did no more bring back the ancient oil lamps than the deprecations of directors and shareholders of gas companies will prevent the electric light from ousting gas as a lighting material. And who but they will regret it? All will rejoice at the prospect of living, breathing, and working in rooms whose atmosphere is no longer vitiated by products of combustion, such as carbon dioxide, sulphur dioxide and others, and where the temperature is no longer artificially raised by the combustion of 85 per cent. of heat-giving gases, contained in ordinary coal gas, which we burn for the sake of its 12·15 per cent. of heavy light-giving hydrocarbons. It was a tempting task, promising a golden harvest, to find a suitable substitute for it; and in no branch of applied electricity has so much ingenuity been displayed as in the construction of the various lamps.—*Fortnightly Review.*

With the Evolutionary Squadron.—Admiral Hornby has issued to the captains and some other officers of the Particular Service Squadron a memorandum requiring them to report to him, in writing, upon a number of questions with reference to the impromptu defence of harbours. The following are some of the points of detail which are to be more especially considered:—The value of the naval electro contact mine; the efficiency of naval electro mechanical mines, and their safety in laying down and picking up; the advisability of using the same circuits for counter mining and for electro contact mines; the efficiency of the present fitting of short branches and disconnectors; whether, if separate circuits were used for electric contact mines, it would not be advisable to lay them on a multiple cable, so that each mine could be separately tested and lifted; the value of the electric light when placed on shore or in boats away from a fleet, and the best means of so placing it; the best means of defence against an attack by fast torpedo boats; the best method of mining defence for a fleet of ships from which all mining stores have been removed, but which are accompanied by one or more torpedo depot ships like the "Hecla;" the safety of such mines as the Pietraski and their value for blocking up an enemy's fleet; whether, if defensive mining stores be not carried in ships, dropping mines, such as the Pietraski, should be carried, &c.

The International Telegraph Conference.—A telegram from Berlin announces that the first meeting of the next International Telegraph Conference, which will assemble in Berlin, has been definitely fixed for the 10th prox. Most of the European and several extra European States have already notified their intention of sending delegates. Nearly all the large cable companies will also be represented. The *Standard* trusts that when the International Telegraph Convention meets it will endeavour to redress two or three grievances which the mercantile community has against the system under which messages are now taxed. One of these grievances is the rule which forces all people who live in, or who have business with, extra-European places, whose names exceed ten letters in length, to pay double price for the transmission of these names. A merchant, for example, telegraphing to or from Buenos Ayres, or any extra-European place, whose name exceeds ten letters in length, has to pay for that name as if it were two words instead of one. In Buenos Ayres alone, we are told, this means an extra tax of at least £100 per annum on telegrams as compared with Monte Video or Rosario. Abbreviation words should be allowed in these cases. Our excellent contemporary forgets or is unaware that it is open to anyone to register a code name (and address) of fewer than ten letters. It is only the negligence of the people to which it refers that has given rise to a fancied grievance.

Carpentier's Circulating Cell.—The essential part of this battery is a syphon with unequal limbs, both of which are plunged in the same vessel containing the exciting solution. In the longer limb are placed the electrodes, consisting respectively of zinc and carbon, and the syphon is filled in any convenient way. So long as the circuit remains open the liquid in the syphon remains homogeneous, and equilibrium is maintained; but as soon as the circuit is closed the zinc dissolves, and increases the density of the liquid in which it is immersed. Hydrostatic equilibrium is thus disturbed, and a circulation of the liquid is established proportional to the intensity of the current. The heavy liquid containing the zinc falls to the bottom of the vessel and remains sharply separated from the fresh solution, whilst the latter continually ascends the short limb of the syphon and is brought in contact with the electrodes. In the cell constructed by M. Carpentier the carbon electrode constitutes one limb of the syphon, and is in the form of a tube, in the centre of which is suspended the amalgamated zinc. The other limb consists of the annular space between the carbon tube and the surrounding glass envelope, communication between the two being established by means of a ring of holes pierced in the upper part of the carbon. The position of the electrodes is so arranged that the level of the exciting liquid is somewhat higher than the ring of holes. Several elements of this form may be placed in one and the same reservoir, if care be taken to isolate them sufficiently from one another by means of glass or caoutchouc envelopes with small apertures at top and bottom.

The Earthquakes.—The returns of the damage occasioned by the earthquake in Cashmere on May 13th state the loss of life at 3,081 persons, besides 25,000 sheep and goats and 8,000 cattle. The number of dwellings ruined is estimated at 75,000. A correspondent of the *Calcutta Englishman* says:—"The force of the earthquake appears to have concentrated itself at certain spots, and there to have spent itself. These spots look as though a large amount of gaseous matter under the earth had, with the strength of dynamite, been struggling for an outlet, and had torn and lacerated the ground at the point where it found an exit. Thus one sees villages with the huts destroyed, the earth adjacent being cracked and split, and the air putrescent from the bodies of cattle buried under the houses, while not 20 yards distant a sloping wooded hill seems untouched. In other places the side of a vertically scarped hill has been sliced off as if by the guillotine, the earth so severed lying at the base. Some hillsides are only partially disconnected, and a deep incision remains. Other hills again present the appearance of an ordinary landslip. Near Lalledourah village three enormous chasms have been formed, one about three-quarters of a mile broad, and 20 feet deep. Not far distant a tract of land 800 yards square has subsided, forming a trench 100 yards long, 50 feet deep, and 30 feet wide."—A severe earth-tremor has been felt in Tasmania, as well as in the colonies across the Straits. At Launceston several chimneys were thrown down or cracked, and the spire of the Scotch Church, which was affected by an earth-tremor last July, has been further displaced.—A severe shock of an earthquake has also occurred at Dongarra, Western Australia. The houses shook for some seconds, and the residents were much alarmed.

The Electric Light in New Zealand.—We have received an interesting account of the trial of an electric search-light in Dunedin. It appears that the Government, early in May last, placed in the hands of R. E. Fletcher and Co., of that city, an order for the construction of an electric search lamp, to be used in connection with the Auckland defences. Similar lamps will in

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due course be supplied to the other principal ports, but in the meantime the first specimen was hurried on, and a trial was made of its power, previous to its despatch to Auckland. The apparatus was conveyed to the heights below Roslyn, in the neighbourhood of the stone quarry, so that use could be made of the Corporation engine stationed near that spot, and this engine, although rather erratic in its working, enabled a very satisfactory experiment to be made. The lamp was what is known as "hand focussing," and provided with a universal motion, so that it could be turned at pleasure by the hand in any direction. It was also fitted upon a small tripod stand, for convenience of transit. The light was projected forward in a steady powerful stream by means of a 22in. parabolic silvered reflector, and when an engine of, say, eight horse-power nominal was used, a bright light was shown to a distance of at least 1,500 yards. The illuminating power of the lamp under these conditions would be about 35,000 candles. On the occasion of the trial, an excellent idea could be obtained of its utility. When the light was directed over the town the spire of the First Church, the Town Hall, and other buildings were distinctly illuminated, whilst within a smaller radius objects were visible as clearly as in broad daylight. Similar lamps have been in use some time at the Australian ports, and there are also three in Tasmania. The idea of having those required for New Zealand manufactured in Dunedin was, however, an afterthought, and Messrs. Fletcher are to be congratulated upon the success of their first experiment.

Litigation in America.—Recently, in the Supreme Court of the United States, an appeal was tried in the case of the Western Electric Manufacturing Company *v.* the Ansonia Brass and Copper Company, in which it was decided that the appellant company's reissued patent for an improvement in insulating telegraph wires, which covers a product, fell with their original patent, which covered a process, for the following reasons :—The process consisted in compressing the wax or other suitable material into the pores of the fibrous covering of the wire without scraping off any part of it. This process was anticipated by letters patent to Dundonald and to Baudouin in this country, which describe the compressing of the wax, &c., to attain the same result, viz., the insulation of the wire. The patent was therefore declared invalid. The difference between the complainant's and the Baudouin process consisted merely in the use of a greater quantity of wax. This might be an improvement on the latter process, but it did not involve invention. The allegation of appellants that one of the features of their process was allowing the wax to cool before compressing it was not sustained by any mention of this feature in either the specification or claim of the patent. As the claim failed to describe this feature, it could not be held to be covered by the patent.—In the Circuit Court of the Southern District of New York the case of the Gold and Stock Telegraph Company *v.* the Commercial Telegraph Company *et al* has also received judgment. The facts are briefly as follow :—The complainants' reissued patent was for an improvement in telegraphic printing instruments for registering the price of gold and stocks by means of type-wheels moving independently, and arranged so as to print jointly or separately upon one strip of paper. This was construed, in view of the state of the art and in the light of the specification, to mean a united action, or action in co-operation, and not a simultaneous action, of the wheels. The defendants alleged non-infringement, for the reason that the wheels of their instrument have a locking device which prevents their moving independently, "because it is a condition of the rotation of one wheel that the other shall first be brought to a state of rest;" but this was not the sense in which the patentee used the term "independently." By it he only meant that one wheel was not linked to the other, so that both must rotate together. As defendants' instrument differed from complainant's only in respect of the locking device, the allegation of infringement was sustained. The complainants' patent, originally issued to the inventor, E. A. Callahan, was applied for in December, 1867, and bore the date of April 21, 1868. An English patent for the Callahan invention bore the date of March 16, 1868, the date of the filing of the provisional specification, and was sealed on August 21, 1868. Upon these facts it was held that the complainants' patent did not expire on March 16, 1885.

The International Telegraph Convention.—On Monday last the Duke of Richmond received at the Board of Trade an influential deputation representing the principal cable companies, on the subject of the Bill now before Parliament, to carry into effect the International Convention for the Protection of Submarine Telegraph Cables. The deputation included the Marquess of Tweeddale, Viscount Monck, Sir D. Gooch, M.P.; Mr. J. Pender, M.P.; Sir G. Elliott, Bart., M.P.; Admiral Sir George Richards, Sir James Anderson, Mr. C. Burt, Mr. Bompas, and Mr. Ford. The Duke was attended by Baron H. de Worms, M.P., Parliamentary Secretary of the Board, and by the private secretaries, Mr. A. West and Earl Cairns. The Marquess of Tweeddale represented to the Duke of Richmond that the companies were advised by several of the most eminent counsel of the day that the present law of England was more favourable to them than the law proposed by the Paris Convention. For the most part, the new Convention would satisfy the companies, but Articles 2 and 4 contained objectionable clauses, inasmuch as they were advised that if the captain of a repairing steamer broke another company's cable he might be liable to five years' imprisonment, even though he could not help breaking it while grappling for the cable he was sent to repair. It was further stated that private enterprise owned 90,000 out of the 100,000 miles of cable in existence, and £34,000,000 of the capital, and that the proposed law, which was designed to protect these enterprises, really made the position of the companies worse than it was at present. The Marquess of Tweeddale further showed that upwards of 20 foreign States were parties to this Convention, so that the captain of an English repairing steamer was liable to be tried in a foreign Court under the terms of the Convention without such protection as English laws or an English judge and jury might give him. It was also shown that this Conference, composed amongst others of such countries as the Argentine Republic, Republic of Costa Rica, Republic of Guatemala, Dominican Republic, United States of Columbia, Persia, Roumania, Servia, and the Republic of Salvador and the Republic of Uruguay, was called together by the Director-General of Telegraphs in France, none of the companies having been invited to attend or being heard on the subject. The Duke of Richmond, in replying to the deputation, reminded them that they had not interfered when the question was before the House of Commons; but the companies replied that the recent laying of the Mackay-Bennett cables had given the question a prominence which it did not possess before—so much so that they had at once obtained the advice of eminent counsel. It is hoped that the Duke of Richmond and the House of Lords will take some time to consider the matter, and not too readily ratify a Convention which has been shown by the parties concerned to be injurious to their interests. The foreign telegraph companies in England are also preparing a petition against the Bill.

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ALTERNATING CURRENTS.

BY THOMAS H. BLAKESLEY, M.A., M. INST. C.E.

(*Continued from page 116.*)

It will be convenient to express the various powers which have been dealt with in terms of the angle A B C, which is the angle by which the difference between the phases of the two electromotives forces falls short of two right angles. Call this angle θ. Also call the angle B A C ϕ, and the angle B A D β.

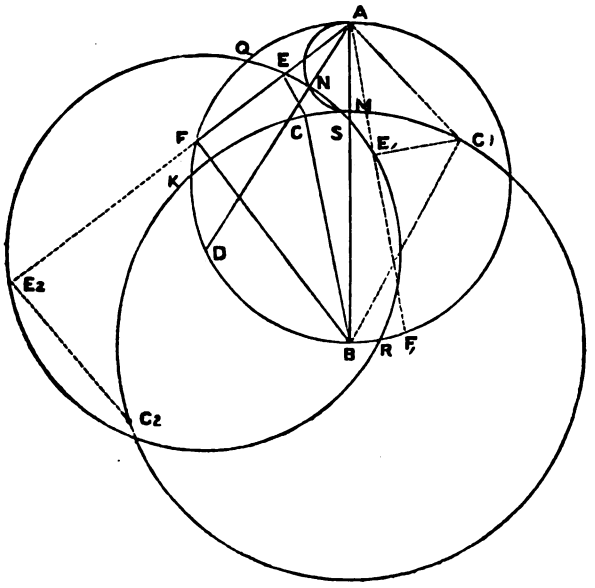

FIG. 16.

It is first to be observed that the triangles D E A, B C A are similar to each other, since each side of the former bears to some one side of the latter the ratio cos β, or geometrically,

$$A E = A C \cos \beta$$
$$E D = C B \cos \beta$$
$$D A = B A \cos \beta.$$

From the triangle A C B, A C : B C :: sin θ : sin ϕ,

or $$A C = f \frac{\sin \theta}{\sin \phi},$$

therefore $$A E = f \frac{\cos \beta \sin \theta}{\sin \phi}.$$

Also from the triangle A B C,

$$\frac{e}{f} = \frac{\sin \overline{\phi + \theta}}{\sin \phi} = \cos \theta + \cot \phi \sin \theta,$$

and from the right-angled triangle A F B

$$A F = A B \cos F A B = e \cos \overline{\phi + \beta}.$$

Hence, A F A E $= e f \cos \beta \sin \theta \frac{\cos \overline{\phi + \beta}}{\sin \phi}$

$$= e f \cos^2 \beta \sin \theta \cot \phi - e f \cos \beta \sin \theta \sin \beta$$

$$A F \; A E = e f \cos^2 \beta \left(\frac{e}{f} - \cos \theta \right) - e f \cos \beta \sin \beta \sin \theta$$

$$= e \cos \beta \{ e \cos \beta - f \cos \overline{\theta - \beta} \}.$$

Therefore, the power at work in source A being $\frac{A F \; A E}{2 R}$ is equal to

$$\frac{e^2 \cos^2 \beta - e f \cos \beta \cos \overline{\theta - \beta}}{2 R} \quad . \quad . \quad . \quad (\alpha).$$

which is in the form desired.

Again, from the triangle C E A,

$$A E = A C \cos C A E = A C \cos \beta,$$
$$\therefore A E^2 = A C^2 \cos^2 \beta,$$

and from the triangle A C B

$$A C^2 = B C^2 + A B^2 - 2 B C A B \cos A B C,$$
$$= f^2 + e^2 - 2 e f \cos \theta.$$

Hence, $A E^2 = \cos^2 \beta \{ e^2 + f^2 - 2 e f \cos \theta \}$,

or the power employed to heat the circuit, being $\frac{A E^2}{2 R}$, is equal to

$$\frac{e^2 \cos^2 \beta + f^2 \cos^2 \beta - 2 e f \cos \theta \cos^2 \beta}{2 R} \quad . \quad . \quad (\beta).$$

The difference between these two powers is the power transmitted, and therefore doing work upon source C. Hence the power transmitted is equal to

$$\frac{e f \cos \beta \cos \overline{\theta + \beta} - f^2 \cos^2 \beta}{2 R} \quad . \quad . \quad . \quad (\gamma).$$

The efficiency of the transmission is found by dividing this expression (γ) by the expression (α) for the power of source A. The efficiency therefore is equal to

$$\frac{f}{e} \left\{ \frac{e \cos \overline{\theta + \beta} - f \cos \beta}{e \cos \beta - f \cos \overline{\theta - \beta}} \right\} \quad . \quad . \quad . \quad . \quad . \quad (\delta)$$

The expression for the power of A shows that it is greatest when $\theta = \pi + \beta$, and least when $\theta = \beta$, but it is always positive so long as $e \cos \beta$ is greater than f. When this is not the case it is possible for the source A to have work done upon it.

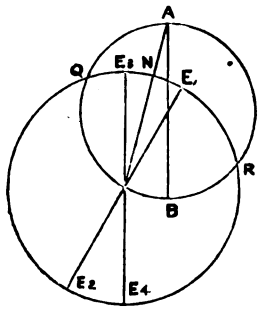

FIG. 17.

In Figure 17, let A B $= e$, and the angle B A D $= \beta$. B D A is a circle upon AB as diameter, whose centre is K. Let D be the centre of the circle which is the locus of E of former figures, cutting B D A in Q and R as before, and A D and A D produced in N and P. Join D K and produce it both ways to cut this circle in E_1 and E_2, the point K being in D E_1. Also draw E_4 D E_3 parallel to B A, cutting the same circle in E_4 and E_3, E_3 D A being equal to β.

Then A D E_3 is the angle giving the value of θ when the power exerted by the source A is least, and A D E_4 (greater than π) is the value of θ for the greatest power of A.

The expression for the transmitted power working on C given by equation (γ) shows that that power is greatest when $\theta = -\beta$, *i.e*, A D E_1 is the value of θ for this condition, and when $\theta = \pi - \beta$, *i.e.*, A D E_2, the power working on C is negative and a minimum, *i.e.*, C *would have to do its greatest work*.

The circle which E describes is now divided in the important points Q R E_1 E_2 E_3 E_4, and from the above considerations we can discuss the question of the stability very conveniently. We shall suppose E to move round in the positive direction.

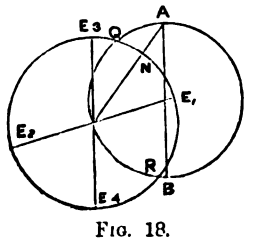

FIG. 18.

As regards the point E_3, it may be observed that if D N is sufficiently great, it will lie outside the circle A D B (as in Fig. 18). The condition that it does not do so is expressed by the inequality $\frac{f}{e}$ must be less than $\frac{\cos 2\beta}{\cos \beta}$ which will be first supposed to be the case. As E moves from E_1 to Q, there

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will be transmission of power to C, from its maximum value at E_1 to zero at Q. Hence, as regards C the motion will be stable, because a retardation of its motion is accompanied by a greater transmission of power to it, and *vice versâ*.

As E moves from Q to E_2, C will do work from zero at Q to its maximum value at E_2.

Hence the motion of C will be stable, because a retardation of its motion is accompanied by a smaller duty, and *vice versâ*.

As E moves from E_2 to R and finally to E_1 there will be instability as regards C.

Again, as regards the source A. As E moves from E_3 to E_4 through E_2 the power exerted rises from its minimum at E_3 to its maximum at E_4. Hence in this half circle the motion of A will be unstable, because any retardation on its part, implying an advance of E, will be accompanied by a greater duty, and *vice versâ*, so that the displacement will be augmented.

As E moves from E_4 to E_3 through R, the power exerted by A diminishes from its maximum to its minimum value. Hence, in this half circle the motion of A will be stable, because any retardation on its part, implying an advance of E, will be accompanied by a smaller duty, and *vice versâ*, so that the displacement is decreased.

Hence between E_1 and E_3 there is absolute stability for both sources, and between E_2 and E_4 absolute instability.

In the remaining regions there would arise a necessity for constraint in one or other of the sources.

Between E_3 and E_2 the source A would need constraint, between E_4 and E_1 the source C would need it.

If both sources are constrained a position of E between E_2 and E_4 becomes a possibility.

Under the conditions, therefore, represented by Fig. 17 it would appear impossible to make both sources do work at the same time without constraint; but this impossibility arises from the fact that E_3 is nearer to N than Q is. When Q is nearer to N than E_3 is, *i.e.*, when $\frac{f}{e} > \frac{\cos 2\beta}{\cos \beta}$, the impossibility is removed, and of the power going to heat the circuit part is provided by each source.

The result may be compared with that furnished by either source working alone, which would be for the sources A and C, $\frac{e^2 \cos^2 \beta}{2R}$ and $\frac{f^2 \cos^2 \beta}{2R}$ respectively, assuming that the other source is constrained to remain at rest.

When both are acting the total power is

$$\frac{e^2 \cos^2 \beta + f^2 \cos^2 \beta - 2ef \cos \theta \cos^2 \beta}{2R}.$$

Hence the gain, if any exist, compared with A working alone is

$$\frac{f^2 \cos^2 \beta - 2ef \cos \theta \cos^2 \beta}{2R}.$$

$$= \frac{f \cos^2 \beta}{2R} \left\{ f - 2e \cos \theta \right\}.$$

For an advantage, therefore, $\frac{f}{e} > 2 \cos \theta$.

Now, θ must be less than β for stability.

Hence an advantage appears possible if $\frac{f}{e} > 2 \cos \beta$, a narrower restriction than $\frac{f}{e} > \frac{\cos 2\beta}{\cos \beta}$, necessary that both sources should do work, with stability.

Both conditions are approached by increasing the value of β, *i.e.*, by increasing the coefficient of self-induction. It is, therefore, only with a comparatively large value of the coefficient of self induction that the stable doing of work by both sources is *possible*, and with a still larger value that it would be *advantageous*.

As to the transmission of power, its possibility is seen to depend upon the value of the angle $E_1 D E_3$, which is simply 2β. The closer E is to E_1 the greater will be the transmission, but it must be remembered that a retardation of E from its normal position between E_1 and E_3 to an equal distance behind E_1 will upset the motion. Thus it will not be desirable to press too closely to the maximum transmission. If E is situated at the point N, the efficiency is not at its maximum value, but it has the value $\frac{f}{e}$, which is the greatest efficiency in transmission with uniform currents. It would thus appear that transmission by alternating currents does not compare unfavourably with that by uniform currents in this respect.

(To be con'inued.)

MORE LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Is electric lighting to have yet another sin laid to its charge? We have had Stock Exchange, parliamentary, and municipal jobbery in abundance, but it now appears that to all these must be added that of combined expert and commercial jobbery. The following will explain my meaning, and is a true story:—

Some two years ago a gentleman (a partner in an electrical firm) suggested to a friend of his, the principal of a very large semi-public institution, the advisability of adopting the electric light. He went to some trouble, and showed him several installations, with the result that at last the principal induced his managing Board to vote the funds for the installation of the light, but with the proviso that the job should be put up for public tender. This was rather hard lines on our friend, who looked upon the job as in some sort belonging to him; but as he knew all the ins and outs of the proposed installation, which was a very peculiar one, he being very intimately acquainted with the requirements of the institution in question, he made sure of obtaining the contract. In due course all tenders went in, and then the managing Board wanted an adviser, being entirely untechnical. They therefore searched everywhere for a competent expert, and finally looking in the *Court Journal*, picked out their man. Unfortunately, they did not know that he was connected with one of the tenderers; but such being the case, he went through the pile of tenders, picking out four which were the only ones of value. At the head of this list, as regards low price, stood our friend's firm, that of the expert's friend being a very bad fourth; but, nevertheless, the *unprejudiced adviser* formulated a lengthy report wherein he stated that the firm who were so far out should be allowed to have their tender back to amend, as they had included machinery, &c., which the others had not estimated for. This was done. Of course, it came back £20 less than the amount of our friend's tender, with the natural result that the aforementioned upright judge's friend got the contract, our original friend who started the matter, and whose tender was lowest, being left out in the cold. All the above could be proved, and comment is needless, but if the publication of this letter will prevent such sharp practice in future its purpose will have been served.—Yours, &c.,

DAMOCLES.

[We are of the opinion that when facts of this kind can be authenticated they should be published, and further, notwithstanding the question of libel, the names should be given, so that for the future those who act in the manner described may be left severely to themselves.—ED. *E.*]

AN ELECTRIC "FRONT SIGHT."—An electric front sight for rifles has been patented by Mr. W. Winans, of Brighton, Sussex. The invention is designed to overcome the difficulty of shooting in the early morning, when the light is not good enough to see the ordinary fixed sight properly. This temporary front sight consists of a very small incandescent or glow lamp (something like a dentist's), covered with a metal shield. The shield has a small hole in it through which the light shines, and this spot of light, being turned towards the shooter, is used as the "bead" of the front sight in aiming; a small electric battery in the stock of the rifle generates the electricity for the lamp. The invention promises to be of use to the sportsman, but it will be found, we think, rather a bother in practice.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

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ANSWER TO CORRESPONDENT.

G. F.—*Yes. Exhaustive information upon the subject of the proper diameter of wires to be used in electric lighting has appeared from time to time in our columns.*

THE SUBMARINE CABLES PROTECTION BILL.

We mentioned last week the Submarine Cables Bill as one of the measures which would probably survive the political crisis. But we also pointed out in a general way that telegraphy and other electrical interests were, on the whole, in better plight now that the political colour of the home Government had changed. Not that we predicted anything in regard to the future; our intention was rather to offer consolation for the present, together with some reasons for hope, even in the unexpected contingency of a return of the present Ministers to office in the autumn.

It would almost seem that in one quarter at least a lively sense of some present obtainable advantage had quickly manifested itself without any prompting from us. Possibly the deputation from the Cable Companies which waited upon the President of the Board of Trade on Monday last may have been arranged with his predecessor; we cannot speak as to that; but we confidently assert that its reception would have been different, and its results, if more decisive, less satisfactory. What the representatives of the Cables asked for was that the Bill, which is in its final stages, may be referred to a Committee, so that the parties most interested may have an opportunity of being heard. What the answer of the late President would have been it is not hard to conjecture. What the Duke of Richmond urged was, not that, being the owners of vast property, the deputation had no right to be heard, but simply that the request came rather late in the day, which is certainly true, and that to put the Bill into Committee now would be to sacrifice it for the present Session altogether, which is probable. The question, then, is, will it be worth while to abandon the Bill, so as to have an amended version of it next year more in accordance with the views of the Cable Companies?

We have no hesitation in saying that if they consider, after due deliberation, that the framing of the existing clauses is dangerously ambiguous, the Companies will be justified in delaying the enactment till next year. By the Convention of Paris the British Government is pledged to enact the penal measures agreed upon there, so that the Bill is not finally endangered. In some form or other it must pass next year at latest; if in the interval the opportunity for amending it will counterbalance the evil of delay, there can be no doubt as to the course that should be taken, for if it is passed in the present Session there will be small chance of amending it in the next. There is, however, one other alternative—namely, the rejection of the Convention itself; and as at present advised, the Companies are rather of opinion that their interests are better safeguarded under existing English law than they would be under the stipulations laid down by the twenty foreign plenipotentiaries in Paris last year.

The Companies have two substantial grievances in this matter. The Convention was a French idea, and it proceeded on purely French principles. Submarine Cables were objects of international concern, therefore the French Government took them under its special and distinguished consideration. As none of the nations convened, save one, had any great pecuniary interest in Submarine Cables, they not unnaturally jumped at the idea of assuming the *quasi* rights of ownership or guardianship over them; and the one exception, the British, as usual, complacently followed suit to please its very dear friends the French. It does not seem to have occurred to the latter—and our own Government took no great pains to enlighten them—that the Submarine Telegraph Cables of the world were almost wholly the private property of British subjects. Of the 100,000 miles of cable, 90,000 belong not to States, but to individuals; and every mile of them has been laid by Englishmen. Yet the terms of the Convention for the regulation and protection of these properties were virtually framed by a French Administration, and the owners themselves had absolutely no voice in the proceedings. The British representatives on the Convention were Government Officials who took no counsel with the parties most interested.

This is grievance number one; the second is, that in legislating to carry out the objects of the Convention the home Government have similarly neglected to acquaint themselves with the real needs of the parties for whom they were legislating. So true is this, that no sooner do the proprietors get a chance of being listened to than they point out several instances of ambiguity and unfairness which the Bill, as it stands, is guilty of, solely because those who understand the subject best have not been consulted. For example, repairers of Cables will run the risk of penal servitude under the rigorous enactments of the Bill if another owner's Cable is wilfully or negligently broken or injured in repairing operations. Seeing that numbers of Cables have been laid across each other, and that the repair of the lower ones—those first laid—may involve injury or breakage to the ones above, some clearer definition of wilfulness and negligence is decidedly called for. As we pointed out in our article commenting on the Convention in the month of May last year, it is a great achievement to have established the principle of ownership, and of international protection for these Cables, and consequently of legal criminality for wilful damage done to property so owned and protected. But it is a heavy price to pay for such favours if the owners themselves are unavoidably to become the first offenders unless they are to refrain altogether from keeping their Cables in repair.

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There are other, if less serious, objections to the Bill as at present worded, and it is no answer to them to say that a jury will determine the questions left in doubt. As a matter of fact juries are directed to find according to law, and are not allowed to amend Acts of Parliament in the Law Courts. We also think that the Duke of Richmond underrates the freedom of action left to each Government under the Convention. Article XII. runs as follows, "The high contracting parties engage to take, or to propose to their respective legislatures, the necessary measures for ensuring the execution of the present Convention, and especially for punishing by either fine or imprisonment, or both, those who contravene the provisions of Articles II., V., and VI." The offences referred to in these clauses are indicated with sufficient plainness; but they are not defined with legal exactness; nor, it seems to us, is their any international obligation to follow the literal wording of the Convention whilst faithfully carrying out its intentions. Article IV., which the deputation particularly object to, is not especially emphasised for legislation in the Convention. It would be better to refuse ratification altogether rather than allow this Article to be embodied in English law.

SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: You have been publishing of late a series of very interesting papers on the subject of secondary batteries, the substance of which agrees very well with my continued experiments and investigations. I notice, however, in your last issue a sentence in the reproduction of Mr. Reckenzaun's paper which I cannot let pass without some rectification, not on account of the implied criticisms on my personal work, but on behalf of pure truth. The sentence runs thus—

"The original Faure battery has never been of any practical service, and very substantial improvements had to be made at enormous cost to bring the secondary battery to a commercial value."

It is easy to understand that practice would bring improvements in the way of applying the lead oxides upon the lead plates, whether perforated or not, but I cannot see what else has been done by the E.P.S. Company, except it be that instead of applying the lead mixture upon the whole surface of the plate they filled the holes only. This certainly saves the cost of the felt or asbestos board I used, but at the cost of an enormous increase in the electrical resistance of the cell and the prompt destruction of the uncovered part of the perforated plate. The original storage capacity of one horse-power hour has also not been maintained with certainty in 40 kilogs.—Yours, &c., C. A. FAURE.

St. Brice, Seine et Oise, France, July 7, 1885.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Though I do not like to differ from such an authority as Mr. Desmond FitzGerald, I must do so in the question as to whether sulphate of lead is formed when a secondary cell is discharged. Mr. FitzGerald argues that a sesquioxide of lead is formed. This is a doubtful, unstable compound, if it exists at all, and it cannot exist in the presence of sulphuric acid, as lead peroxide and lead sulphate would be formed. The high electromotive force of the secondary battery shows that there are very powerful chemical affinities at work, and the mere change of degree of oxidation can hardly produce such an effect. I feel no doubt that the action of the battery is due to the affinity of the Pb for the SO_4, the equations being, on one side $2PbO_2 + 2H_2SO_4 = 2PbSO_4 + 2H_2O + O_2$, on the other $Pb_2 + 2H_2SO_4 + O_2 = 2PbSO_4 + 2H_2O$. The appearance of the coating of an ordinary discharged peroxide plate does not prove the absence of sulphate, for only a very small proportion can be sulphate. Some years ago, when I made a large number of experiments on batteries, I found that in no case more than six or seven per cent. of the coating is used, even when the cell is completely run down. The expansion of the peroxide of lead in becoming sulphate perhaps blocks the coating up. The specific gravities of the oxides being taken, gave roughly the following volumes for 100 volumes of metallic lead:—Litharge 151, red lead 148, peroxide 160, sulphate 297. The formation of sulphate can be shown by using the impervious form of peroxide, as on discharging a thin white film appears on the surface only. On the spongy lead plate, again, the appearance cannot be taken as a guide, but if sulphate of lead is not formed, what is? We know that no oxide of lead but peroxide can exist in the presence of sulphuric acid. Probably only a small percentage of of the spongy coating can ever be made available. The difficulty of reducing ordinary precipitated lead sulphate has misled many people. This substance is a very troublesome insulator, and it seems to be a question of contacts. I have passed electricity through a cell with this sulphate for five weeks without reducing more than a few particles; but if a little red lead or litharge is mixed with it it reduces quite easily. A very white coating of lead sulphate on a Planté plate reduces perfectly.

Peroxide of lead can easily be made from precipitated lead sulphate, but it is too loose for battery coatings, owing to the small volume of the particles of peroxide formed.—Yours, &c.,

JAS. SWINBURNE.

36 and 37, Bermondsey-street, S.E.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the last issue of your journal Mr. FitzGerald controverts the now generally-accepted explanation of the chemical changes involved in the discharge of a secondary cell, and puts forward the idea that the unstable Pb_2O_3, which, as chemists well know, is decomposed by weak acids, and therefore could hardly be expected to exist in a secondary cell containing sulphuric acid, is formed by the reduction of the PbO_2 on the negative plate. The writer, however, gives no experimental data for his conclusion.

Some three years ago Dr. Gladstone and I communicated to *Nature* our results in elucidation of the chemical changes involved in the charging and discharging of secondary cells. One of the conclusions to which these results led was that both the peroxide of the negative plate and the finely-divided lead of the positive were converted into lead sulphate during discharge. Since these investigations were published I have found that the amount of sulphuric acid which actually passes from solution in the discharge of a secondary cell substantially agrees with the amount calculated from the equation deduced from our observations, which not only confirms our conclusion, but shows that Mr. FitzGerald's speculation has no foundation in fact.

In the case of cells where peroxide of lead is in contact with lead, I have found a greater disappearance of acid than our equation allows, but the interpretation of such a result is easy, since we know that such cells discharge themselves more or less by local action.—Yours, &c., ALFRED TRIBE.

Dulwich College, 9th July, 1885.

POTENTIAL DIFFERENCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I hope to meet your correspondent's views as concisely as possible.

The law of Dr. G. S. Ohm may be stated comprehensively thus. The current in a circuit varies as the algebraical sum of all the separate sources of E.M.F., and inversely as the sum of all the resistances in that circuit.

Further, between any two points in a circuit the current varies as the difference of potential between those points plus the algebraical sum of all E.M.F.'s acting between them, and inversely as the sum of the resistances between them.

Thus V and V^1 being the potentials at the points, ΣR the total resistance between them, and ΣE the algebraical sum of E.M.F.'s acting between them, we have

$$C = \frac{V - V^1 + \Sigma E}{\Sigma R}$$

(E.M.F.'s positive in direction of current, and *vice versâ*.)

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If there is no additional source of E.M.F. between the two points, we have simply

$$C = \frac{V - V^1}{\Sigma R} \quad (\Sigma E \text{ being } nil.)$$

and when a complete closed circuit is considered we have

$$C = \frac{\Sigma E}{\Sigma R} \quad (V \text{ and } V^1 \text{ being equal}).$$

It is certainly advisable when symbols are employed to know what they mean. A move has been made lately to introduce a universal notation; but as so many terms, each with their own subdivisions, now exist, the difficulty seems to lie in the scarcity of symbols. It suffices, however, to use any symbols, *provided* it is stated at the time what they are intended to mean. I see no reason for surprise that any single letter should stand briefly for the difference of potential between the ends of a resistance, if it be distinctly stated at the outset to bear that meaning.

Of course if the meaning assigned is ignored and another one substituted, a fine field is opened for discussion of imaginary points, and a "confused mind" can then easily take E.M.F. and difference of potential as the same thing, or imagine others to do so.—Yours, &c.,

H. D. WILKINSON.

School of Electrical Engineering, Hanover-square.

THE ELECTRIC LIGHT FOR MINES AND HOUSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: "Electricity," as *The Times* very truly observed when commenting the other day on the disastrous Clifton Hall Colliery explosion, "is the one illuminating medium which can supply the light which miners want, without the flame which endangers them;" and the writer added that "the public cannot compel, though it may encourage, scientific brains to exert themselves as keenly for the illumination of a murky, dirty coal pit, as for the transformation of a plot of ground in South Kensington into fairy land."

As "one who knows" how thoroughly the progress of novel applications of electricity is at the present time paralysed by the want of encouragement from the public, I would venture to emphasise the gentle hint conveyed in this last paragraph, and to quote so practical an authority as Mr. Hammond, who, at the winding-up meeting of his company on the 17th of last month, gave as the reason of their inability to light Lombard-street and the immediately surrounding streets of the City (notwithstanding the exceptionally favourable conditions they had secured), that no one could now be persuaded to subscribe £100 towards carrying out electrical installations. "There were many persons," he said, "who were greatly interested in the electric light, but it had some deadly enemies who believed that every man connected with it was a thief."

The reaction against the large electric light companies is unreasonable when extended to electricity itself. But the public does not discriminate; it lost money through the blind rush which it made a few years ago, *ergo* electricity is moonshine and a failure.

But if central stations throughout London will probably be postponed for some time to come, then there is all the more reason for examining and encouraging other means for introducing the beautiful and wholesome light of incandescent lamps, not alone into murky mines, but also into the well-furnished houses of those who reside in the neighbourhood of the South Kensington fairy land; and that such means do exist is a fact of which I should wish to mention one example.

A gentleman residing in one of the handsome houses in Queen's-gate has, during the past two months, had his dining room floor most effectively lighted by means of a small primary battery located in the cellar under the pavement of the street. It is contained in three small boxes, each of which can be easily and conveniently charged or discharged in a few minutes by any unskilled person.

There are seven incandescent lamps in the hall, nine in the dining room, four in one sitting room, and three in another; each can be separately lighted or all simultaneously, and the intensity of the light can be raised or lowered just as with gas. Besides these there is one movable lamp attached to a long silk-covered double bell wire, and employed, as a miner might use such a lamp, for searching into shaded corners, or for more closely examining the beautiful pictures which hang upon the walls of the dining room.

Here, then, is an electrical current produced without engine power of any kind, without noise, without skilled labour, at very little more cost than gas in London, and by means of a handy apparatus, which a couple of miners could easily move forward from time to time, following the progress of their work. One such box, three or four feet long, and about a foot square, will supply 20 miners each with a small lighted lamp of three or four candle-power, at distances ranging up to 20 or 30 yards from the box.

At the house at Queen's-gate it produces a more brilliant light in lamps of about 15 candle power, of which the steadiness and constancy is absolutely perfect, fitted on electroliers (artistically and exquisitely designed by Osler, of Oxford-street), which make it inimitably effective for drawing room or dining room lighting.

But just now the British public seems to be as unwilling to encourage, as it is unable to compel, scientific men to produce any electrical novelty, for it taboos the inventors; and, strange to say, it is a foreigner whose house is so charmingly lighted in Queen's-gate.

Inventors, according to Virgil, will find their reward beside the poets in Elysium—

> "Quique pii vates et Phœbo digna locuti;
> Inventas aut qui vitam excoluere per artes."

—Yours, &c., M. I. C. E.

July 2nd.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I note your reprint of the discussion which has been going on in *The Times* relative to the electric lighting of collieries. As I have been engaged during the past nine years in the introduction of electrical apparatus to collieries, perhaps my views on the subject may be of interest. We have already introduced the electric light underground into two large collieries, and on the surface in several others; and in one of the former, at the time the lights were put in, they were placed in many situations where no naked lights were at that time allowed to be used, with very good results. We are now about to fit up a third colliery in the north, and there are others in this and other districts that have been lighted by other firms.

It will readily be understood that, under the circumstances, I should be the last to place any difficulties in the way of its general adoption, which, I hope, will not take long to accomplish. At the same time, I think Lord Thurlow is taking a rather too *couleur de rose* view of the question. There *are* considerable mechanical and scientific difficulties in the way of its adoption in many parts of the mine, but principally at the working face, where it would be of most value in every respect. In this district especially—South Wales—falls of roof are of constant occurrence, even on some of the main roads; while at the face of the coal, in every mine, the ground is constantly changing. The face itself is constantly moving forward as the coal is worked, and the operation of getting the coal involves in most cases the falling of huge masses, so that no fixed light would be of the slightest value, or could live long. To complicate the matter there is always the danger of a spark passing when wires are broken, as they inevitably would be.

On the other hand, no primary battery or accumulator has yet been produced of such a weight that the miner could carry it, of such a size that he can place it in positions where he now hangs his safety lamp, and, at the same time, that will give him a light that will be of service to him and last the time he requires, which should be close upon ten hours, allowing for the time going to and from his work.

By dint of reducing the amount of light on the one hand and its duration on the other, a few fairly portable lamps have been produced, but they can hardly be called practical miners' working safety lamps. There is no difficulty whatever

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in lighting the main roads, pit bottoms, &c., as though there may still be a slight element of danger, it is hardly appreciable, and not to be considered in comparison with other constant sources of danger that are always present. Remembering that it is necessary that there shall be a certain mixture of gas and air in a certain part of the mine, which is constantly swept by a very strong current of air, that a spark shall take place at the point where the gaseous mixture has accumulated; seeing that, except in the case of a rare accident, there is no chance for a spark to pass, and further that it shall pass *through* the gas, the conditions usually being that the gaseous mixture rises to the roof, while the lamp is kept fairly low down—remembering all these necessary conditions before an ignition can take place, where the lamps are not exposed to falls of roof, &c., while there is absolutely no other danger from the use of the incandescent light, I think that we may fairly call it, for safe positions, mechanically, a perfectly safe lamp; but for the face of the coal, where it is most wanted, much remains to be done before we can hope to see it generally adopted there. In my opinion the future lighting of the working face will be by means of lamps attached to supply wires led to a convenient point near, and not by means of portable lamps, unless a radical improvement takes place in the form and duration of accumulators. Our greatest hope lays, in my opinion, in the spread of the rudiments of electrical knowledge among those who have to use the light. This must be, especially in this case, a question of time; but once the working collier realises the fact that he can have a *good* light, better than anything he has ever dreamt of, by merely attaching a couple of small wires to other wires near, and the other ends of these wires to the lamp, he will not be long in availing himself of it; and he may be safely trusted in the large majority of cases to keep his lamp and wires out of harm's way, as soon as he understands that an accidental breakage may mean the loss of his light, and consequent stoppage of his work.

I presume that I need hardly dwell upon the other advantages of the light; but one point may be interesting. An electrically lighted colliery is invariably well lighted; whereas, with every other illuminant, so far as my experience goes, the reverse is the case. Moreover, as an illuminant, the incandescent lamp lends itself to conditions, such as strong draughts of air, that no other does; and it is *so* convenient and can be arranged *so* easily.

One more point. Lord Thurlow hints at legislation to render the adoption of the electric light underground compulsory. If I may be allowed, I would most strongly deprecate such a measure as unjust to colliery owners, and unwise in the interests of the electric light itself.

My experience is that colliery owners, above all others, are ready to adopt a new thing and to give it a fair trial once it can be shown that it is in a practical form. In the early days of the adoption of new things, however, there are too often failures through the promoters of the novelty being insufficiently posted in the difficulties they have to encounter.

In the early days of electric signalling in mines there were many failures from this cause, with the result that in a large number of cases their adoption was retarded for a number of years.

What we, who believe in the future of the electric light, and who hope to see it generally adopted, not only in mines but in factories and in our own homes, have to do is to work steadily on, meeting and conquering the difficulties as they arise, not shutting our eyes to them. By doing this I am confident that we need have no fear of the result, and that we shall need no such extraneous aids as compulsory legislation. That is my experience in the past, and I am full of confidence for the future.—Yours, &c., SYDNEY F. WALKER.

Cardiff, July 4, 1885.

COLLIERY EXPLOSIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the interesting correspondence on this subject which you reprinted from *The Times* last week, primary batteries were alluded to by Mr. Radcliffe Ward, and incandescent lamps of 20 candle-power were spoken of by Lord Thurlow, as suitable for lighting mines with safety. Miners would, however, be quite satisfied with lamps of from two to three candle-power, and primary batteries for lighting such lamps could be made of a very portable and convenient size, because no more than six or seven large cells would be required to furnish a score of miners each with a lighted incandescent lamp, protected from breakage by a small cage of wood or wire gauze, with which they could move about at distances ranging up to 20 or 30 yards from the battery.

The light so supplied would cost less than half the price of candles, or, at an equal cost, the miners might be provided with more than double the amount of light they have when using candles, as the following figures, based upon working experience with my primary battery, will show.

A primary battery now in use and supplying to the lamps an average current of 385 watts per hour when worked for five hours daily—each lamp taking 1 ampere and 24 volts—will light 16 lamps of 10 candle-power, or furnish an amount of light equal to 160 sperm candles. (The smaller lamps of 2½ candle-power require only 1 ampere and 6 volts per lamp.)

This battery is refreshed daily with 1½ gallon of solution, costing 1s. 7½d. per diem, or at the rate of £29. 13s. 1½d. per annum, and consumes zinc at the rate of 2½lb. per diem, costing, at 16s. 4d. per cwt., £6. 13s. per annum.

The maximum annual cost of the electric light in the house in question (supposing the lamps to be kept alight for five hours daily throughout the year, or for 1,825 hours per annum) would be as follows:—

Cost of acids	£29	13	1½
Cost of zinc	6	13	0
Renewal of the lamps	3	4	0
Interest and depreciation of battery (prime cost £30), say	5	9	10½
Total cost of sixteen lamps of 10 candle-power, five hours daily, or for the light of 160 candles during 1,825 hours per annum	£45	0	0

This amount of light is equal to what would be obtained in a mine by burning 160 tallow candles daily for 365 days, or a total of 58,400 candles, which, *at one halfpenny each*, would cost *£121. 13s. 4d. per annum.*

It may be interesting to add a comparison of the cost of the above-mentioned sixteen incandescent lamps of 10 candle-power with that of an equal number of ordinary "fish-tail" burners (No. 4), which most lovers of the electric light would consider to have less illuminating power than incandescent lamps of 10 candle-power.

The cost of gaslight, as it is usually supplied, viz., in fishtail burners, is habitually under-estimated, for each burner, under the ordinary pressure of $\frac{20}{10}$ths, consumes at the rate of 10 cubic feet of gas per hour (as I am prepared to substantiate).

We have therefore: 16 fishtail burners consume in five hours 800 cubic feet of gas, and $365 \times 800 = 292{,}000$ cubic feet, at 3s. per 1,000 cubic feet, cost the consumer *£43. 16s. per annum*, to which must be added the rent of the meter and leakage.—Yours, &c., O. C. D. ROSS.

15 and 17, Relf-road, Peckham Rye, S.E.,
July 7th, 1885.

[We insert this letter because of the importance of the subject. Of course our readers will understand that the figures are Mr. Ross's own; and it is evident, moreover, that that gentleman has not fully considered many of the difficulties which will necessarily attend the use of primary batteries for the purpose set forth.—ED. *E.*]

LIGHTING THE CITY OF LIEGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We notice in your paper this week a reference to an alleged offer made by the Thomson-Houston Company to light the city of Liege gratuitously for a time. We beg to say that this is not correct, and are glad that our company is not reduced to the level of many European companies who are often willing

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to put in plant and run it for the sake of being able to point to their numerous (fictitious ?) contracts.

With respect to the present case, however, the matter stands thus :—A tender for 400 arcs has been sent in, with the proviso that to commence with the company would run 45 arcs for three months for nothing, provided the city would at the end of that time buy the 400 light plant at the tender price, should the lamps and machine have run satisfactorily for the three months, but that if their performance did not come up to promise they would take up their plant and walk.

This they are prepared to do, not only in Liege, but in any city on this side the Atlantic where business is meant.—Yours, &c.,

LAING, WHARTON, AND DOWN.

8 and 9, Holborn-viaduct, July 6, 1885.

ON THE CALCULATION OF MAINS FOR THE DISTRIBUTION OF ELECTRICITY.*

BY W. H. SNELL, ASSOCIATE.

(Continued from page 146.)

The accuracy of our results in each case will now depend, as far as this process is concerned, upon the accuracy with which we can find the value of A. In some cases, as in the first, this can be done very completely. We will now go through these cases in succession.

(1) N_1 *with* N_1'.—These groups can never run contemporaneously. Therefore we have A = *o*, and the formula reduces to

$$N_a = \sqrt{(N_1^2 + N_1'^2)} \quad . \quad . \quad . \quad . \quad . \quad (29)$$

(2) N_a *with* N_2.—By means of Table I., find the total annual number of lamp-hours for this group (IA.), and put this equal to $m\,q_r$ where q is the total number of hours of running per annum. The value of q may be obtained from column B ; if the lamps are not in use on every day of the week, it must be multiplied by the proper fraction ($\frac{6}{7}$ or $\frac{5}{7}$, &c.) Now, during the whole annual period of q hours during which Group IA. is at work, the number of lamps burning in Group I. remains constant at its first value, equal to n_1. If we assume (as will most usually be the case) that no work is performed by Group II. during this period, we shall have

$$N_b = \sqrt{\left(N_a^2 + N_2^2 + \frac{2\,n_1\,m\,q}{Q}\right)} \quad . \quad . \quad . \quad . \quad (30)$$

(3) N_b *with* N_3.—This case is a little more complex. Assume, first, that the section has only one installation belonging to Group II. As before, let α and ω represent the respective times of use and disuse of the building ; and let t' be the mean annual number of hours per day from dusk up to time α, and t'' the same up to time ω. Also put

$$p = \frac{n_\alpha + \ldots . n_\omega}{\omega - \alpha + 1}.$$

So that p is the arithmetical mean of the successive values of n (for Group I.) during the time $(\omega - \alpha)$; these terms of n will be taken from the table formed for Group I.

Then we shall have

$$A = \frac{2\,(t' - t'')\,d_3\,m\,p}{Q}.$$

If α = 8 p.m., or any later hour, we shall get

$$(t' - t'') = (\omega - \alpha).$$

This is also the case when the lamps are always lit at the given hour, α, whether there is still daylight or not.

Thus, for one installation in Group II.,

$$N_c = \sqrt{\left\{N_b^2 + N_3^2 + \frac{2\,(t' - t'')\,d_3\,m\,p}{Q}\right\}} \quad . \quad . \quad . \quad (31)$$

Take, now, the case in which there is more than one such installation upon the section.

Let $k_1, k_2, \ldots$ be the actual numbers of lamps in each, and let $K_1, K_2 \ldots$ be the numbers corresponding to the thermal currents which have been found for each respectively. If, as might possibly happen, these installations are regularly used concurrently, or very nearly so, we should merely have to put

$$N_3 = K_1 + K_2 + \ldots$$

and

$$m = k_1 + k_2 + \ldots$$

and to insert these values in (31). In the more general case the expression for A will have the form—

$$A = \frac{2}{Q}\Big(d_1\,t_1\,k_1\,p_1 + d_2\,t_2\,k_2\,p_2 + \ldots\ \delta_1\,t_{01}\,k_1\,k_2 + \ldots .$$
$$\Delta_1\,t_{001}\,k_1\,k_2\,k_3 + \ldots .\Big) \quad . \quad . \quad (32)$$

where $d_1, d_2, \ldots$ is the total number of days of running for each installation per annum ; $\delta_1, \delta_2, \ldots$ is the number of days on which each (possible) pair of installations run together ; $\Delta_1, \Delta_2, \ldots$ is the number of days on which each set of three installations run together ; and so on. Also $t_1, t_2 \ldots$ are the values of $(t' - t'')$ for each installation ; $t_{01}, t_{02}, \ldots$ are the values of $(t^{\text{III.}} - t^{\text{IV.}})$ for each pair of installations, where $t^{\text{IV.}}$ is found in Table I. for the time when the two installations *begin* to be running together (that is, the time corresponding to α for the later of the two), and $t^{\text{III.}}$ is found for the earlier of the two values of ω. $t_{001}, t_{002}, \ldots$ are similar values found in the same way for every three installations ; and so on.

By a similar development of equation (26) we should get for the value of N_3 an expression of the form

$$N_3 = \sqrt{\left[\frac{1}{Q}\left\{d_1\,t_1\,k_1^2 + \ldots\ \delta_1\,t_{01}\,(k_1 + k_2)^2 + \ldots\right\}\right]} \quad (33)$$

(4) N_1'' *with* N_3''.—This case is the same as the last, being the Sunday work for the same groups.

(5) N_c *with* N_d.—This case is similar to case (1), collating the total Sunday work with the week day work.

(6) N_e *with* N_4.—This case deals with the "Irregular" lamps; it is therefore impossible to obtain any definite value for A, and we can only make a choice for N_f between the limiting values.

(7) N_f *with* N_5.—N_5 being the "daylight work" the periods are exclusive, and we have

$$S_a = \sqrt{(N_f^2 + N_5^2)}.$$

Having thus obtained the values of the thermal current proper to each separate section of the system, we have now to find the "final thermal current" when the section is considered *in situ* and (unless a terminal section) transmits current to sections beyond. In the case when any given section transmits *the whole* of the current for one or any number of sections beyond, there is no difficulty in determining at least the limiting values of the final thermal current by the formulæ already considered. Now, in his recent Cantor lectures, Professor Forbes has shown that the above condition is a characteristic of *any* system in which the highest economy is attained. Referring to the "network" system, where the current has more than one path to a given lamp, he says "we should [in this case] have to choose our conductors exactly of the same size as we have chosen them here, and should have exactly the same conditions. If our conductors were chosen of the proper size for the current flowing, then the current would in that case [the 'network'] flow along exactly the same channels as under the system I have been describing [the 'multiple tree' system]. That would be the case when we had the maximum number of lamps on."

In this last sentence, if the size of the conductor is based upon the value of the thermal current, we may, I think, venture to insert the expression $\phi\sqrt{\frac{T}{t}}$ in place of the "maximum number ;" $\phi\sqrt{\frac{T}{t}}$ being the number of lamps corresponding to the final thermal current when the period is reduced from T to t hours ; t being the mean daily period during which the major part of the work is done, as in (8) and (11). Thus this

*Paper read before the Society of Telegraph-Engineers and Electricians.

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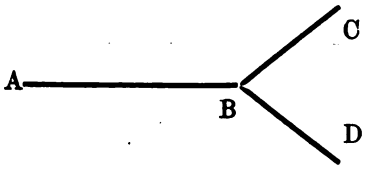
expression is very nearly the mean number of lamps which burn together.

It will therefore be sufficient to consider as a type the case in which two terminal sections, B C and B D, unite with the section A B.



Let the "proper thermal current" for B C correspond to S_1 lamps, that for B D to S_2 lamps, and for A B to S_3 lamps, then we shall have for the numbers corresponding to the final thermal currents,

$$\phi_1 = S_1; \qquad \phi_2 = S_2$$

$$\phi_3 = \sqrt{(S_3^2 + x^2 + B)},$$

where $$x = \sqrt{(\phi_1^2 + \phi_2^2 + A)};$$

so that $$\phi_3 = \sqrt{(S_3^2 + \phi_1^2 + \phi_2^2 + A + B)}.$$

And if the number of lamps alight in each half-hour (from 6 p.m.) be for B C, $p_1, p_2, \ldots$; for B D, $q_1, q_2 \ldots$; and for A B, $u_1, u_2, \ldots$ we shall have

$$A = \frac{1}{T}\{p_1 q_1 + p_2 q_2 + \ldots\}$$

(the coefficient reduces to $\frac{1}{T}$ because the values of p and q are for half-hours); and also

$$B = \frac{1}{T}\{u_1 (p_1 + q_1) + u_2 (p_2 + q_2) + \ldots\}$$

(To be continued.)

PHYSICAL SOCIETY.

At a recent meeting of this society the following papers were read:—

"*On the Winding of Voltmeters.*" By Profs. W. E. Ayrton and John Perry.—As it is most important that voltmeters, ohmmeters, powermeters, and ergmeters should be so constructed that the percentage increase of resistance of their fine wire coils due to the heating effects of the currents passing through them should be as small as possible, the question arises as to whether such coils should be made of German silver wire, or of copper, or partly of German silver and partly of copper wire, and how the diameter of the wire should vary in different parts of the coil. The authors have therefore been led to investigate the conditions that make this heating error a minimum with cylindrical coils of internal and external radii, r_0 and r_1.

At a place whose distance from the axis is r let the cross section of the wire be x_1, ρ the specific resistance of the material; then, assuming that

$$x = x_0 r^a, \quad \rho = \rho_0 r^b, \quad \rho x = \rho_0 x_0 r^c,$$

and that a current, c, in one spire of radius r produces a magnetic effect, KCr^d, on the suspended needle, they find that the heating error is proportional to

$$r_0 \rho_0 \frac{p^2}{(r_1^p - r_0^p)^2} \cdot \frac{n}{r_1^n - r_0^n} \cdot \frac{r_1^m - r_0^m}{m},$$

where $p = d - a + 1$, $n = 2 + b - 2a$, $m = 2 + 1{\cdot}144\, b - 4a$. The conditions that make this expression a minimum are worked out in the paper, the result being that with one of their magnifying spring solenoid instruments where $d = -1$, the values of a and b giving a minimum value are $a = 0{\cdot}325$ and $b = -0{\cdot}5$, and since in practice b cannot be negative they conclude that $b = 0$ and $a = {\cdot}4$ give the best results, *i.e.*, that all the wire employed in the bobbin should be of copper, and the law of increase of cross section proceeding from the centre should be $x = x_0 r^{0{\cdot}4}$. The actual waste of energy in the instruments is next considered, and lastly the authors show how to pass from a voltmeter with known winding, and whose maximum reading is P_1, to another of the same volume and shape whose maximum reading is to be P_2, and they conclude that as they have shown that the waste of energy is the same in both for their maximum readings, the resistances of the instruments must be proportional to the squares of P_1 and P_2, or following the law already arrived at for a minimum error due to heating, the cross sections of the wires of the two instruments at similar places must be inversely proportional to P_1 and P_2. The employment of outside coils for voltmetres is considered, and it is shown that if we desire the same error in the two instruments due to heating when the outside resistance coils are of the same size and shape, it is necessary to have the same ratio between the resistance of resistance coil and that of the magnetising coil in the two cases. To have a less or a greater error in the second case it is only necessary to have the equation

$$c\,(\text{the error}) = \frac{2 + F\,V}{1 + F\,V}.$$

where F is a constant and V the volume of the German silver resistance coil. From this V may be determined and the ratio $\frac{R_1}{R}$ of the resistances of the resistance coil and the magnetising coil is given by $\frac{R_1}{R} = \frac{F}{D}\,V$, where D is a constant which, like F, is obtained from experiments on the first instrument. The diminution of the heating error by using much iron in the instrument so as to obtain the same magnetic action with a much smaller current is discussed, and experiments were shown to illustrate how such employment of iron introduced a permanent magnetism error, and caused the indications of such an instrument on the lower part of the scale to be uncertain, and to depend upon whether measurements were being made with an increasing or a diminishing current.

"*On the Manner in which Light affects the Resistance of Selenium and Sulphur Cells.*" By Mr. Shelford Bidwell.—In a communication made to the society at its last meeting, the author had described a sulphur cell which behaved in all respects like a selenium cell when exposed to light. The action of this cell was supposed to be electrolytic, the sulphur containing a small quantity of sulphate of silver. If this were the case the result of the current traversing the cell would be to deposit sulphur upon the anode, and as sulphur has an enormous resistance, that of the cell would increase unless the sulphur thus deposited combined with the silver. It is this combination that is believed to be much facilitated by light, a supposition the author believed he had confirmed by direct experiment. Mr. Bidwell had also measured the resistance of a piece of selenium that was believed never to have been heated in contact with a metal. The specimen was crystallised by heating for some time in a glass mould, two opposite sides cleaned, and two pieces of tinfoil, between which the resistance was measured, pressed against them. In this way the specific resistance was found to be 2,500 megohms, which is enormously higher than that of the selenium in the "cells," a fact tending to confirm the theory that the conduction in such cells is due to the electrolysis of the selenides of the metals forming the terminals produced in the "cooking," and similar to that of the sulphur cell described above.

At another meeting of the society, Prof. Guthrie, President, in the chair, Dr. Ramsey, Messrs. T. Hands, F. W. Sanderson, W. A. Shenstone, and F. H. Nalder were elected members of the society. The following communications were read:—

"*On the Specific Refraction and Dispersion of the Alums.*" By Dr. J. H. Gladstone.—The refraction, dispersion, and specific gravity of nineteen different alums in the crystalling form were published by M. Charles Soret, of Geneva, in the *Comptes Rendus* for last November. These, together with some additional data from Soret, Topsöe, and Christianson, were employed by the author for comparison with certain experimental results of his own and of Kannonikof. In this way additional proof was obtained that a salt has the same specific refraction whether it be crystallised or dissolved, and that the refraction equivalent of a compound body is the sum of the refraction equivalents of its components. The refraction equivalents of the alkalies in these alums are in the following ascending order:—Sodium, potassium, ammonium, rubidium, methylamine, calsium, and thallium; and of the other metals, aluminium, chromium, and iron. This is in accordance with what was previously known, but Soret's observations do not afford the means of determining the equivalents more accurately than before. The refraction equivalents of indium and gallium were determined for the first time, giving respectively 17·4 and 14·8. The specific dispersion of the same compounds, measured by the difference between the specific refractions for the lines A and G, was also examined. The differences of dispersion are much greater comparatively than the differences of refraction. The order was also determined, but not the actual dispersion equivalents of the different elements.

"*On a Form of Standard Daniell Cell, and its Application for Measuring Large Currents.*" By Dr. J. A. Fleming.—The author first referred to the careful and thorough investigation of the circumstances affecting the electromotive force of Daniell's and allied cells by Dr. Alder Wright. He then described a form of all that had been found most convenient and reliable in practice. It consists of a U tube, in the two limbs of which are the two solutions of sulphate of copper and sulphate of zinc of the same specific gravity. Electrodes consisting of freshly electro-deposited copper and pure zinc that has been twice distilled dip into the two limbs. The E.M.F. of this cell is 1·102 and the variation of E.M.F. with temperature is practically *nil*.

"*On the Phenomenon of Molecular Radiation in Incandescent Lamps.*" By Dr. J. A. Fleming.—Some years ago Dr. Fleming had called attention to a phenomenon in incandescent lamps very analogous to that of discharge in high vacua observed by Mr. Crookes. The inner surface of the lamp-glass was sometimes found to be coated with a deposit of carbon, with the exception of a clear line marking the intersection of the glass with the plane of the loop, and being, in fact, a shadow of the loop apparently caused by an emission of matter from the terminals. Dr. Fleming has since found how to produce this appearance at pleasure by passing a very strong current momentarily through a lamp, and has succeeded in obtaining similar deposits of various metals that had been used as terminals. These deposits show colours by transmitted light, and as a general result the

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TABLE II.

Name of Sample.	Carbon Pencils. Length.	Weight.	Specific Gravity.	Ground Carbon. Weight.	Specific Gravity.
Brush	5 centimetres.	7·8035 grammes.	1·526	2 grammes.	1·587
Wallace	do.	8·5667 ,,	1·571	do.	1·806
Boulton	do.	7·7162 ,,	1·516	do.	1·606—1·540 Average, 1·573
Buffalo—plain	do.	7·7272 ,,	1·523	...	.....
Buffalo—graphite core	do.	7·0540 ,,	1·415	do.	centre core, 1·699 / exterior, 1·594
Buffalo—vitrified	do.	8·5961 ,,	1·598	do.	1·865
Carré	do.	8·6091 ,,	1·506	do.	1·885—1·914 Average, 1·8995

author concludes that red metals, such as gold and copper, appear green by transmitted light, whereas white metals, like silver and platinum, appear brown, a conclusion which, however, was challenged by Captain Abney in the discussion ensuing.

"*On Problems in Networks of Conductors.*" By Dr. J. A. FLEMING.

"*Lecture Experiments on Colour Mixtures.*" By Captain ABNEY.—The apparatus employed by Captain Abney is a modification of Maxwell's colour box; the spectrum, instead of being formed upon a screen, is received upon a convex lens, which forms an image of the face of the prism upon a screen. If all the light from the prism falls upon the lens, this image is colourless, but by interposing a screen with a slit in the spectrum, close to the lens, so as only to allow light of a given colour to fall on the lens, the image appears coloured with that light. By using two or more slits different lights may be mixed in any required proportions.

"*On Stream-lines of Moving Vortex-rings.*" By Prof. O. J. LODGE.—The communication described a method of drawing vortex stream-lines consisting in superposing uniform motion represented by a series of parallel lines upon the lines of a stationary vortex as given by Sir W. Thomson in his memoir on vortex motion, and joining up the corners of the quadrangles so formed. This operation is very simple, and by its application a number of the more remarkable properties of vortex-rings may be obtained, the general analytical investigation of which involves mathematical methods of the highest order. Drawings were exhibited showing the nature and behaviour of a single votex-ring moving with different velocities, a vortex-ring approaching a large distant obstacle, the chase of two unequal rings, and many other cases.

"*On the Thermo-electric Position of Carbon.*" By Mr. J. BUCHANAN.—It having been observed that the carbon filaments of incandescent lamps usually gave way at the negative end, experiments were instituted to find if the destruction could be due to the "Peltier effect" causing a local generation of heat. Observations on a platinum carbon thermo-couple showed that a generation of heat would result from a current passing from carbon to platinum, but the effect was too small to account for the observed phenomenon. It was found that a couple of carbon iron rose considerably in E.M.F. by maintaining the hot joint for some time at 250° C.

"*On Some Further Experiments With Sulphur Cells.*" By Mr. SHELFORD BIDWELL.—The paper contains (1) a description of a class of cells which give a constant voltaic current, the electrolyte consisting of a solid metallic sulphide; (2) an explanation of the unilateral conductivity exhibited by selenium and by sulphur cells; and (3) a description of a cell which gives, as the result of passing current through it, a current in the same direction as the primary current.

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(Continued from page 106.)

REPORT OF EXAMINERS.—*Section VI.—Carbons.*

In addition to the experiments mentioned in our last, two other experiments were made, as follows: The pencil was broken up in the mortar and the finest particles separated by the sieve; the coarser grains were weighed, thrown into distilled water and boiled. The water was then cooled down to 60° F., the granules transferred to the specific gravity bottle and a new determination made. In both cases the specific gravity was much higher than that of the finely powdered portion of the same sample, as will be seen from Table II.

This would seem to indicate that some volatile gas was driven off during the process of boiling. A further observation was made, viz., that the material composing the pencils is not of uniform density. When the sample is finely powdered, thrown into water and stirred with a glass rod, a portion sinks, but another portion (somewhat like an oily scum) floats upon the surface. This is doubtless some pitch or tar compound used to cement the materials together. Most of the carbons used in actual practice are coated with a superficial layer of copper, and as this would render specific gravity determinations of no value, the plain carbons only were used, with the exception of one sample exhibited by the Buffalo Company, covered with a coating of borate of lead. There was also a carbon pencil examined having the peculiarity of a central core (resembling graphite) a little larger in diameter than the core of an ordinary lead pencil. It was noticed when these different determinations were tabulated that the specific gravity of the powdered carbon was (as might be expected) in each case greater than that of the pencil, and furthermore that the pencils showing the highest specific gravities were not made from the densest materials. Considerable difference was also noticed in the hardness of the different samples.

The figures given in Table II. are the average of two weighings of the same sample after drying.

The following table shows the specific gravity of the two coarsely powdered samples which were boiled in distilled water:

Brush carbon.....	2 grammes taken	sp. gr., 1·908
Carré	do.	sp. gr., 1·982

5. *Microscopical Examination of Thin Transverse Sections of the Carbons.* This was made by Dr. Persifor Frazer and yielded the following very interesting results. The examination of the five thin sections of the electric light carbons submitted was undertaken with an 8-10 Zentmayer lens and a Beck parabolic reflector. The sections were in fair order (with the exception of some dirt on the inner surfaces of the cover glasses) except that No. 5 was broken across the cover glass, and the latter as well as the carbon section detached from the slide.

No. 1 was taken from a Brush carbon, No. 2 was taken from a Wallace carbon, No. 3 was taken from a Boulton carbon, No. 4 was taken from the Buffalo Company's carbon, No. 5 was taken from the Carré carbon.

The preliminary examination was made without a reflecting mirror, and with a low eye-piece, giving a magnifying power of about 50 diameters.

No. 1. Under these circumstances No. 1 presented an opaque surface, except in a few spots where the film was torn away, and a few translucent particles. The colour of its surface was silver grey, with foliated masses of carbon of decidedly graphitic appearance distributed through the field. Under the reflected light of the parabolic mirror the substance of the section, though of coarser structure than appeared in the other slides, seemed of considerable constancy of composition. The largest grains were about 0·1 mm., and the smallest 0·03 mm., the latter measurement quite accurately representing the size of the pores. All the bright spots are surfaces showing high metallic lustre and grey colour, with lines of striation and fracture.

No. 2. Without the reflector No. 2 presented the appearance of a fine-grained surface covered with small rounded nodules or minute botryoidal masses, and showed little if any traces of foliation or crystallisation. Under reflected light (and exposed on the underside to a parallel beam) the largest opaque grains were 0·03mm. and the smallest 0·015mm. The average size of the opaque grains was 0·02mm. These are, in a rough estimate, from 1 to 2 per cent. of visible foreign matter in the carbon in the form of grains of various substances (which are generally translucent) in the carbon. Some of these reach a size of 0·1. There are fewer pores in this than in No. 1, but those which exist are larger. The largest part of the substance is very fine-grained, but large dark grey angular discs are very generally distributed throughout the mass. In the photograph these dark grey flat bodies are visible, and the constituent parts of the fine mass are less sharply defined and separated. But, in fact, the photograph cannot give either the colour or the lustre of the original, and is mainly useful in giving an idea of the texture of the surface.

No. 3. Without the reflecting mirror No. 3 showed an extremely fine-grained texture, with comparatively few and quite small points of silver-gray colour and metalloid lustre. Under the mirror the grains measured from 0·05 to 0·02. The texture was extremely fine-grained and compact, and the structure exceedingly homogeneous. The colour of the surface was a lighter grey than that of any of the other slides, and was tinged yellowish in irregular blotches, which may however have been the result of the accidental addition of a foreign body in mounting. Occasional translucent oblong particles were seen measuring 9·1 mm. to 0·05 mm. along their longer sides. The surface exhibits small and large masses of slightly greenish colour attached to each other, and nowhere separable into distinct grains. The smallest of these constituent parts are not so small as those of the matrix of No. 2; and the largest not as large as the dark angular fragments in the same slide. The structure is nowhere compact, but loose and spongy. There are visible a few small striated particles of irregular outline.

No. 4. Without the mirror the texture appears very fine, but little granular in character. The very small points of steel-grey colour of graphitic aspect are less numerous than in 2 and 3. With the reflector the grains varied in size from 0·01mm. to 0·03mm., the average being rather nearer to the first measurement. The colour was a somewhat darker grey than that of No. 3, and the number of very minute particles

* From the *Journal* of the Franklin Institute.

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of foreign matter was greater; most of these were translucent, and measured about 0·02mm.

No. 5. Examined simultaneously in reflected and transmitted light. No. 5. shows a very large number of holes, which have doubtless been caused by the more ready crumbling of certain of its constituent grains. Those of the latter which are opaque measure from 0·02mm. to 0·01mm. The grains are not so fine as in the last specimen, and the structure seems to be less homogeneous. From the existence of numerous very fine points of various colours in transmitted light, and the existence of the holes formerly mentioned, it would seem that the powdered carbon has been mixed with very fine sand or earth, either accidentally or purposely, before having been moulded into sticks. The ground mass has a fine grained, dark greenish appearance, of the same character as that of 3 and 4, *i.e.*, resembling a surface of a decomposing mineral. A number of dark grey, flat, angular objects are scattered through the mass as in No. 2.

Resistances of Arc Light Carbons.—The following measurements of resistances of electric light carbons were made at Cornell University last winter. The carbons were selected at random from those which Prof. Sadtler procured for tests, and probably represent a fair average. The method pursued in measuring the resistances was as follows:—The carbon to be tested was connected in circuit with a piece of very uniform German silver wire, a known length of which measured 1-10th ohm. To connect the carbon in the circuit, a hole, which the carbon fitted tightly, was bored in the side of a wooden block, and a second hole bored from the top of the block to meet the first. Such a block was fitted upon each end of the carbon and the vertical holes filled with mercury. Into this the connecting wires were placed. The resistance of the carbon was determined by obtaining, upon the German silver wire, points having the same difference of potential as points on the carbon near the two ends. Measuring the distance between these points on the German silver wire, and comparing with the known length for 1-10th ohm, gave the resistance of the carbon. To determine the points of equal difference of potential, a Thomson galvanometer of 10,000 ohms resistance, differentially wound, was used. The coils were adjusted so that no deflection occurred when the same current flowed in opposite directions through them. Their resistances were also adjusted to exact equality. The terminals of one pair of coils were then connected with points near the ends of the carbon, and the terminals of the other pair with sliding contacts on the German silver wire. The method of using the instrument will now be evident. It was far more sensitive than was necessary for the purpose, but could nevertheless be used with great facility. The measurements were made by Mr. E. T. Turner, a young man doing some post-graduate work in my laboratory. The results are given in Table III.

TABLE III.—*Resistances of Carbons.*

—	No. of Carbons.	Resistance per Centimetre in ohms.	Total Resistance of 30 c.m.
Wallace (plain).....	1	0·0048	0·134
	2	0·0044	0·132
	3	0·0047	0·141
Ditto (coppered)	4	0·0044	0·132
	5	0·0031	0·093
Buffalo Company (vitrified)...	1	0·0050	0·150
	2	0·0066	0·198
	3	0·0061	0·183
Brush (plain)	1	0·00610	0·183
	2	0·00623	0·187
	3	0·00672	0·222
	4	0·00691	0·2274
Ditto (coppered)	1	0·00108	0·0329
	2	0·00033	0·0092
	3	0·00024	0·007
Buffalo (plain)	1	0·00625	0·187
	2	0·0052	0·156
Ditto (coppered)	1	0·00221	0·0764
	2	0·00940	0·0145
	3	0·00075	0·022
*Cored (plain)	1	0·1413	4·239
	2	0·1700	5·100
Ditto (coppered)	1	0·000422	0·01266
	2	0·001617	0·04851
Boulton (coppered)	1	0·00163	0·0489
	2	0·00218	0·0654
	3	0·000475	0·001425
Carré (plain).....	1	0·00408	0·1224
	2	0·00377	0·1131

* This was a hollow carbon having a core of some different material. To make sure that the high resistance was not a mistake, it was measured also in the ordinary way by the bridge, with the same results.

SIXPENNY TELEGRAMS.

In the House of Commons on Tuesday last Dr. CAMERON asked the Postmaster-General whether he could inform the House how much of the £500,000 estimated as required to prepare for the proposed introduction of sixpenny telegrams on the 1st of August had yet been expended; and whether he proposed to proceed with the Postal Telegraphs Bill with or without provision for free addresses, as proposed in the amendment to the Bill of which he recently gave notice.

Lord J. MANNERS: With reference to the first part of the question, I have to say that the whole sum of £500,000 will be spent in making the necessary arrangements. With respect to the second part of the question, I would remind the hon. member that the Chancellor of the Exchequer laid down on Monday night the lines which the Government would wish to follow with reference to legislation. My right hon. friend said that it was the desire of the Government not to proceed further with legislation of a contentious character. Now, the object of the Bill to which the latter part of the question refers is to abolish free addresses on telegrams, and that is a question which has been very much contested in the House and outside. I think, therefore, that the Government will not be disposed to proceed further with this Bill during the present session. A fact bearing upon the finance of this question has recently been brought to my notice. It has been calculated by the officers of the department that if the estimate of the contemplated increase of business mentioned by my predecessor in office were realised, there would be an additional outlay required in the course of about four years amounting probably to not less than £1,000,000. This outlay would be necessitated by the erection of underground wires from London to the principal towns of the kingdom. I may also say that the scheme proposed by this Bill could not under any circumstances be brought into operation before October. Therefore, weighing all these considerations together, the Government are of opinion that it would be inexpedient to proceed further with this measure this session, and that it would be wise to remit the whole question to the next Parliament.

Mr. SHAW-LEFEVRE asked whether the Government would give the House an opportunity of discussing the subject. If no such opportunity were given, great dissatisfaction would be felt.

Mr. PULESTON wished to know whether the calculation to which the Postmaster-General had alluded was a new one.

Lord J. MANNERS said it was an estimate which he found in his office, and of which he had not heard previously.

Mr. SHAW-LEFEVRE said he had no knowledge of any such estimate.

Lord J. MANNERS: I have given the facts as they have been given to me in the office.

During the course of the further business of the House, Mr. SHAW-LEFEVRE desired to add a few words on the subject of the Telegraphs Bill. From what had fallen from the noble lord that evening he had gathered that it was the intention of the Government to drop that measure. The announcement that the Government did intend to drop that measure would cause surprise and regret throughout the country. For many months past the expectation had been held out that a considerable change would be effected in the telegraph rate during the late autumn, and he desired to bring under the attention of the Government the financial effects of dropping that measure. He could not help thinking that the Government had not sufficiently considered the fact that £500,000 had been spent upon new plant which would be necessary in case the cost of telegrams was lowered from 1s. to 6d. Moreover, a very large staff had been taken on at the Post Office with a view of introducing the new tariff during the coming autumn. Twelve hundred persons had been taken into the service of the Post Office within the last few months in view of the reduction of the tariff and the increased work which that would throw on the department, and their salaries would amount to £61,000 per annum. Those persons, who were now learning their business, could not be utilised in any other way in the Post Office, and as they could not be dismissed the money expended upon their salaries would be altogether thrown away. The noble lord had given two reasons for abandoning the Bill. In the first place he had misdescribed the Bill, because he had said it was a Bill for charging the addresses. That was a misdescription of the measure, which was a Bill for altering the tariff and for enabling a short telegram to be sent for sixpence instead of for a shilling. In order to confer this very great boon of sixpenny telegrams upon the public it had been found necessary not to allow the addresses to be free. If free addresses were allowed it would involve a very great loss to the revenue, which, taken together with the reduction of price, would amount to some £200,000 per annum. Among the other reasons which the noble lord had given for abandoning the proposals contained in the Bill was that he had received information from the department that if the change was carried out in the manner proposed by the Bill the increase of business which would result from it would occasion an expense of an additional million to the country in the course of the next three or four years. For his own part he thought there must be a misunderstanding on this point, as he had received no information from the department to that effect. He was under the full impression in consequence of the information which he had received from the department, that the half million of money which had been asked for during the current year would amply suffice for purchasing the plant rendered necessary by the anticipated increase of business which would be caused by the reduction of the tariff. It had been calculated that that increase of business would amount to about 30 per cent. on the present business, and he believed that the new plant which had been provided would be amply sufficient to meet that increase in the amount of business. Should there, however, be in successive years a still greater increase of business than that now anticipated there would also be a corresponding increase in the profits of the department, which would amply suffice to meet any additional charge for plant that might be rendered necessary by the increased business. If

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the Bill were to be now dropped all the expenditure which had already been incurred during the present year would be lost to the country. He suggested that the noble lord should proceed with the Bill, and introduce in committee any alternative tariff which he might desire to propose, but he must say that he did not believe that within the financial limits which would be sanctioned by the Treasury the noble lord could propose any other tariff than that set forth in the Bill. Should, however, the noble lord think fit to propose any alternative tariff he could promise him that it should receive his most favourable consideration. He was satisfied that there was a general desire on the part of the House that the Bill should become law, and that the reduction in the tariff to sixpence should be made as soon as possible. He thought it would be desirable that the Government should give one day to discuss the Bill in committee. He rather thought, however, that now the noble lord was responsible for the department, and had an opportunity of discussing the matter with the very able officers at its head, he had discovered that it would be impossible to comply with the rule that the telegraphic department should be a paying one and at the same time to propose any alternative tariff. There was only one other argument—namely, that in the general election it would be a great boon if this reduced tariff should be brought into effect. There would then be a good opportunity of testing it, and he believed the system would be enormously availed of.

Lord J. MANNERS said he wished to remove an erroneous impression from the mind of the right hon. gentleman. He had no intention whatever of removing the Bill from the orders. He proposed to let it remain on the order for the right hon. gentleman to avail himself of if necessary.

Mr. SHAW-LEFEVRE asked would the noble lord give him an opportunity of proceeding with the Bill.

Lord J. MANNERS said he should do all he could to give the right hon. gentleman that opportunity. In the short time that remained, if he could not formulate an alternative scheme, and if he did not satisfy himself or the Treasury, then he would fall back on the scheme of the right hon. gentleman and see what could be done. He wished to point out that he had confined his amendment to free addresses. He had said that whatever was suggested the addresses should be free. He was still of that opinion, and that the abrogation of free addresses would be a very serious loss and inconvenience. The right hon. gentleman had again spoken of the introduction of sixpenny telegrams. But the Bill would do nothing of the kind. It would introduce an eightpenny, a ninepenny, or a tenpenny telegram. No doubt that would be a very good and useful diminution, but he protested against it being spoken of as a Sixpenny Telegram Bill. As to the outlay the right hon. gentleman was aware that it was not the practice in the office to prepare estimates for three or four years in advance. When he came to inquire into the question on the basis of the increased business which the right hon. gentleman himself anticipated, he found that it was calculated that at the end of three or four years an outlay of about a million for underground wires and other matter would have to be incurred. That was the statement he had before him, and it came upon him with great surprise, but he never supposed or suggested that the right hon. gentleman was in possession of those figures when he made his statement to the House. He thought it well, however, when the question arose as to proceeding with the Bill in the present Parliament to state the facts to the House.

COMPANIES' REPORTS.

The Eastern Telegraph Company (Limited).

Report and accounts of the Directors for the half year ended 31st March last to be presented to the twenty-sixth half-yearly ordinary general meeting at Cannon-street Hotel on the 16th inst. at one o'clock:—

The revenue for the period amounted to £371,682. 19s. 11d., from which are deducted £91,599. 14s. 2d. for the ordinary expenses, and £44,815. 4s. 7d. for expenditure relating to repairs and renewals of cables, &c., during the half year. After providing £2,775. 16s. 2d. for income-tax, there remains a balance of £232,492. 5s., to which is added £30,364. 5s. 6d. brought from the preceding half year, making a total available balance of £262,856. 10s. 6d. From this balance there has been paid—

Interest on debentures and debenture stock	£27,370	13	9
Dividend on preference shares	20,384	13	7
An interim dividend of 1¼ per cent. on the ordinary shares	47,500	0	0
	£95,255	7	4

Leaving a balance of £167,601. 3s. 2d., from which £100,000 has been carried to general reserve. The Directors now recommend the declaration of a final dividend for the year ended 31st March, 1885, of 2s. 6d. per share, and a bonus of 1s. per share, amounting to £66,500, both payable on the 16th inst., making, with the three previous payments on account, a total distribution of 12s. per share, or 6 per cent. for the year on the ordinary shares. The balance of £1,101. 3s. 2d. shown at the foot of the revenue account is proposed to be carried forward to the next half year. The revenue includes £11,700 dividend for the half year upon the Company's shares in the Eastern and South African Telegraph Company. Also £2,600 net receipts for the same period on the shares of the Black Sea Telegraph Company belonging to this Company. The Directors of the Eastern and South African Telegraph Company have resolved to duplicate their cable between Zanzibar and Mozambique. This section has been interrupted during the spring months of each year since the cable was laid, causing loss of traffic to the companies, and great inconvenience to the Imperial and Colonial Governments and the mercantile community. The duplication will be charged to the reserved fund of that Company. An arrangement has been entered into by the Company with the Turkish and Greek Governments for the laying of a duplicate cable between Syra and the Island of Chios, 100 miles. The several sections of the Company's cables, and the land lines in connection therewith, are in good working order, with the exception of the 1870 Aden-Bombay cable, which is now under repair. The Company's two cables between Aden and Bombay were both interrupted on the 3rd June. One of the cables was repaired on the 27th June, and the communication by the other line can be restored with one or two calm days. The joint purse agreement with the Indo-European Telegraph Company prevented any serious loss of revenue. The steamship "Electra," referred to in the last report, has proved a valuable addition to the Company's list of repairing ships, having already effected four important repairs. The cost of the ship has been charged to the capital account. To meet the further requirements of the service it has been found necessary to build another steam ship, larger than the "Electra," with twin screws, and the Directors have entrusted the work to Messrs. R. Napier and Sons, the builders of the "Electra." The Directors have purchased on satisfactory terms the buildings at Alexandria and Port Said, previously rented by the Company, as offices and quarters for the staff.

Business Notice.—Mr. H. Thorpe has transferred his manufacturing premises to 34, Eagle-street, Red Lion-square, W.C. The offices and warehouse continue to be at 59, Theobald's-road, London, W.C.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. July 8.		Business Done Week Ending July 8. Highest.		Lowest.	
Anglo-American	27½,	28½	28¼		27½	
Do. Preferred	47,	48	47¾		47¾	
Do. Deferred	7½,	8½	8		7¾	
Brazilian Submarine	11,	11¼	11⅜		11 1-16	x.d.
Cuba	11⅜,	12¼	—		—	
Do. Preference	18,	19	—		—	
Direct Spanish	1½,	2	—		—	
Do. Preference	11⅜,	12½	12½		11½	
Direct United States Cable	8½,	9	8¾		—	
Eastern Telegraph	11⅜,	12	11⅜		11⅜	
Do. 6 per Cent. Preference	13½,	14	13¾		13½	
Do. 5 per Cent. Debentures, 1899	106,	109	108½		—	
Eastern Extension	12⅜,	13	13		12⅜	
German Union	9½,	9¾	—		—	
Globe Telegraph and Trust	6⅞,	7⅛	7⅛		6 15-16	
Do. Preference	12⅜,	13½	13 1-16		12 15-16	
Great Northern	14,	14½	14½		14 1-16	x.d.
Indo-European	31,	32	—		—	
Reuter's	7½,	8	—		—	
Submarine	185,	195	187		—	
West India and Panama	⅞,	1	13-16		—	
Do. 1st Preference	8,	8½	8⅜		8⅛	
Western Brazilian	5⅞,	6⅛	6 1-16		6	
Western Union 7 per Cent. 1st Mortgage	120,	124	122		121	
Do. 6 per Cent. Sterling Bonds	103,	105	—		—	

TELEPHONES.

Consolid. Telephone and Maintenance	⅛,	¼	⅛		— x.d.
Oriental	⅛,	⅜	—		—
United Telephone	11½,	11¾	11 13-16		11½ x.d.

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1⅞,	2¼	—		—
Do. (fully paid)	3½,	3¾	—		—
Hammond Light (£3 15s. paid)	⅛,	⅜	—		—
Swan	⅜,	⅝	—		—
Maxim-Weston	⅛,	¼	—		—

MISCELLANEOUS.

Telegraph Construction	36,	37	37		36½
India Rubber, Gutta Percha, and Telegraph Works	24½,	25½	24⅞		24½

TRAFFIC RECEIPTS FOR JUNE, 1885.

Companies.	June, 1885.	June, 1884.	Increase.	Decrease.
Brazilian Submarine	—	—	—	—
Cuba Submarine	3,000	3,168	—	168
Direct Spanish Telegraph	1,833	1,836	—	3
Direct United States	—	—	—	—
Eastern Extension	37,846	37,585	261	—
Eastern Telegraph	—	—	—	—
Great Northern	24,840	—	—	—
Submarine	—	—	—	—
West Coast of America	4,200	—	—	—
Western and Brazilian	—	—	—	—

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THE INTERNATIONAL INVENTIONS EXHIBITION.

We have mentioned in previous articles that for the first time on this side the water the opportunity is given at the Inventories of studying the Thomson-Houston system of lighting. At the late Exhibition of the Franklin Institute at Philadelphia this system attracted attention, and has since come even into greater prominence in the States. This part of our review of the Inventories being merely descriptive we make no attempt at comparison, but we may venture so far to say that this exhibit has "performed successfully." Whether the machine is more efficient electrically, or more simply constructed mechanically, are questions to be considered elsewhere; suffice it for the present that the light from the lamps is steady and good, and the machine seems to do its work well. The reputation gained by the Thomson-Houston system in the States proved an incentive to business men in England, and several opened negotiations with the American company to take up the agency in England. Perhaps we are divulging no secret when we say that instead of writing letters and waiting replies, Mr. Wharton, of Laing, Wharton, and Down, took the business-like plan of telegraphing across the Atlantic that he had started to negotiate in person. He went across to America, and gained his object, coming back as agent for the Thomson-Houston system. The exhibit, therefore, at the Inventions Exhibition is under the control of Messrs. Laing, Wharton, and Down. It consists of one 45-light 2,000 candle-power dynamo machine, running 38—40 lamps in the East Gallery, and the balance about the gardens at each end of that gallery; one 18-light 1,200 candle-power dynamo machine lighting the East Arcade and the East Annexe; one 6-light 4,000 candle-power dynamo machine, lighting gardens. The two latter machines are running a high-speed Armington and Sims' engine. The 45-light machine is also running on the stall in the East Arcade eighteen incandescent lamps of 8 candle-power each by means of a special distributing arrangement, and two lamps each of 1,000 candle-power.

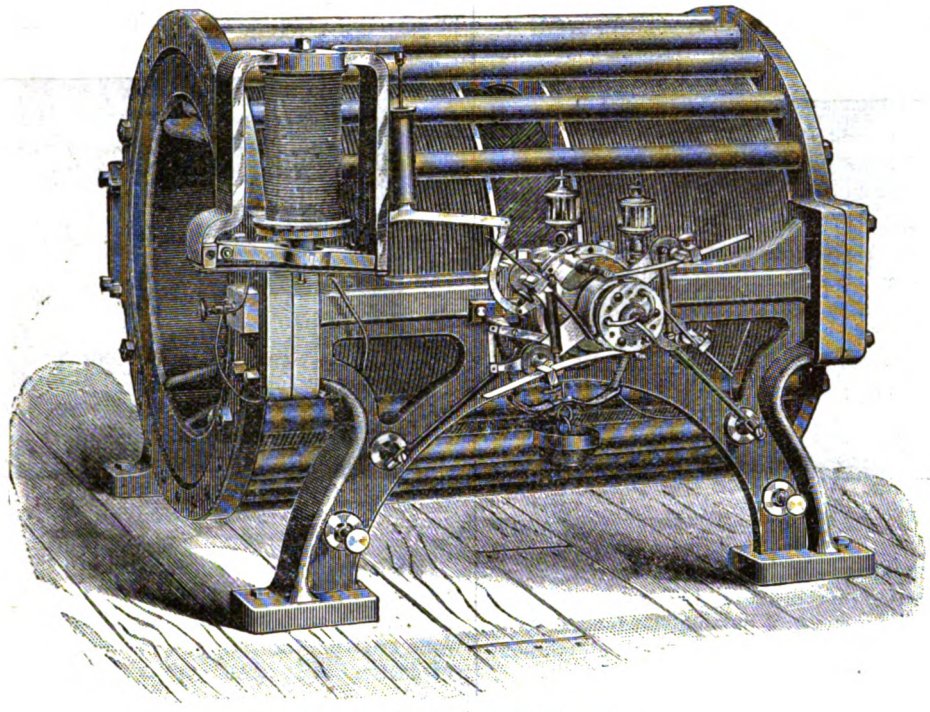

Fig. 1.—Thomson-Houston Dynamo.

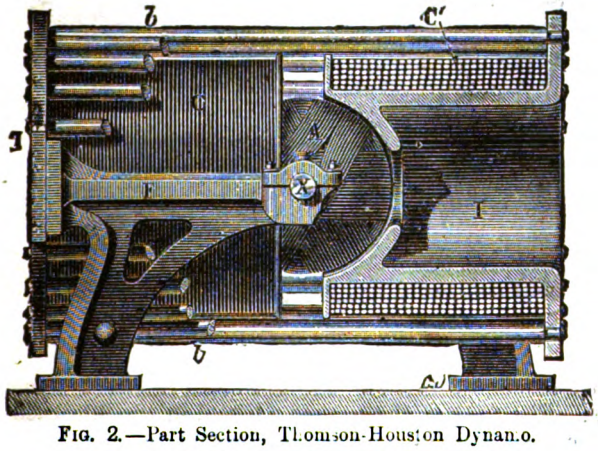

Fig. 2.—Part Section, Thomson-Houston Dynamo.

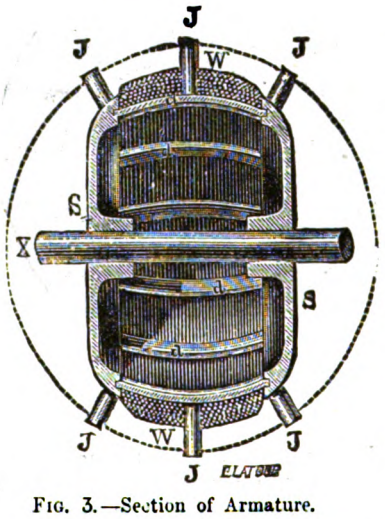

Fig. 3.—Section of Armature.

Before describing the machine, it may be well to give a list of the merits claimed for it by the company, although it seems to us that in the majority of cases these so-called merits are possessed in common—or rather, we should say, claimed in common—by almost all dynamos. The merits set forth are as follows:—1. Extreme simplicity, there being only three coils of wire on the revolving portion, or armature, and three pieces of copper in the commutator. 2. The complete enclosure of the armature by the coils and magnets of the machine, concentrating the power where it should be applied to produce

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the best results, and preventing injury to the moving parts, or danger to the machine from iron objects being drawn into it. 3. The highest efficiency, due to the enclosure of all the wire of the armature where the electricity is generated, by a most powerful magnetic field, giving great saving in horse-power to produce a given result. 4. The spherical form and small size of the revolving portion or armature, giving the least possible air resistance or loss of power by fanning air. 5. The form and size of the armature, preventing the possibility of injury due to centrifugal force. 6. The compact and encased condition of the parts, such as insulated wire, rendering them not subject to injury by contact with surrounding objects. 7. The continuous character of the current and its consequent advantages. 8. The machine

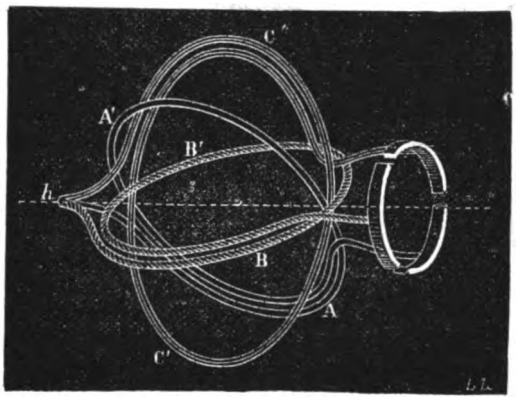

FIG. 4.—Winding of Coils of Armature.

possesses the simplest commutator in the world, giving continuous currents; and from its construction there is no danger of injury to its insulation, so often the cause of putting the generators of other systems out of service. With the air-blast attachment oil may be freely used on the commutator, and the wear of its segments and of the brushes then amounts to almost nothing. 9. The generator requires less attention to keep in order than any other, and with the automatic regulator attached its power is adapted to the number of lights it is desired to maintain. 10. There is little noise or hum produced during

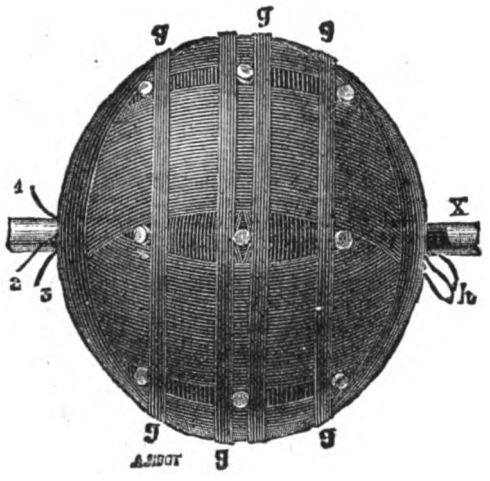

FIG. 5.—Complete Armature.

running, so often an objectionable feature of other generators. 11. The wearing in the boxes is reduced to a minimum by the lightness and balance of the revolving parts. 12. The thoroughness of insulation of all its parts, where needed. 13. The replaceability and interchangeability of its important parts. 14. The freedom from risk of short circuits, the potentials being so distributed as to secure this result.

The Thomson-Houston dynamo differs considerably in external appearance from most other dynamos. It embodies the joint work of Elihu Thomson and Edwin J. Houston. Fig. 1 shows the external view of the machine, while Fig. 2 shows some parts in section. We may say here that we are indebted for these illustrations to the courtesy of the American Company and Messrs. Laing, Wharton, and Down. A frame, F F, carries the bearings for the shaft of the armature, and also supports the field magnets, which consist of two hollow cylinders. The inner end or pole piece of each cylinder is hollowed out spherically, having a central opening, so that when the two are placed in position they enclose a spherical space, in which the armature revolves. At their outer ends the cylinders are flanged, and form the annular plates, as shown. These plates are connected by the iron bars *b b*, shown in Figs. 1 and 2. It will easily be seen that these soft iron bars form the central portion of the magnet core; at the same time they act as a protection to the wire C of the field magnets.

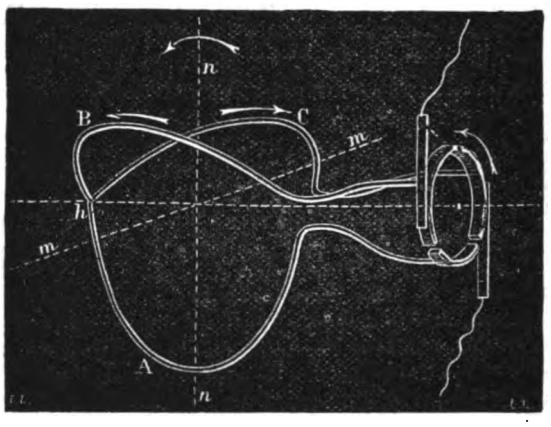

FIG. 6.—Direction of Currents.

Coming now to the armature, which occupies the spherical space before mentioned between the poles of the field magnets, it will be found to consist of three coils of wire wound around an iron core, resembling in form an ellipsoid of revolution. The iron core is built of two concave plates, *s s*, as shown in Fig. 3, keyed to the shaft. The edges of the plates are bridged over by the light iron pieces *d d*. There are generally 12 of these cross pieces, whose ends are carried in circular grooves in the rim of the iron plates. On these bridge pieces are wound a quantity of well annealed soft iron wire, W W, varnished to insulate the various machines. The wire used varies with the design of the machine. Wooden pieces, J J J, are inserted in the

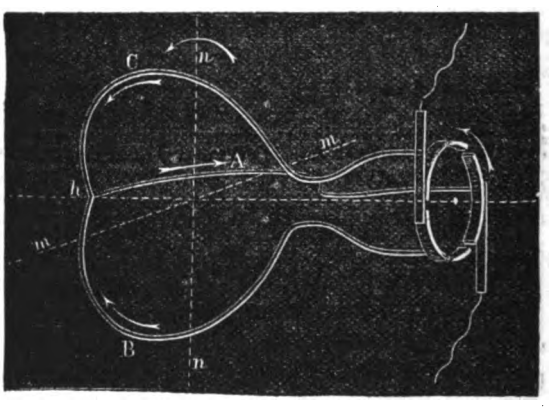

FIG. 7.—Direction of Currents.

edges of the plates S S acting as guides for winding the coils. Fig. 4 shows the method adopted in winding each coil. The coils, three in number, are wound at angles at 120° relatively to one another, as will be seen from the figure. It will be noticed that the three entering wires are joined together at *h*, while the three outgoing wires have their ends joined to the three equal segments of the commutator.

When the armature, shown complete in Fig. 5, is to be wound, the core is first covered with thick paper, which is made to adhere by a varnish of gum lac. Then, commencing at *h*, one-half of the first coil is wound; the core is then turned 120° and one-half of the second coil is wound. The third coil is also commenced at *h*, but is wound full length.

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Then the second half of the second coil, and finally that of the first coil are completed, over the surfaces corresponding to their first halves. The inner ends of the wires are connected at *h*, as stated above, and the external ends are carried to the sections of the commutator, the points at which the various coils cross each other being covered with insulating material. It will also be noticed that the crossing of the coils increases the thickness at certain points, so that the final shape of the

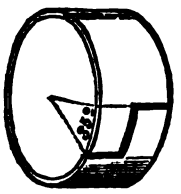

FIG. 8.—Old Form Commutator.

armature more nearly resembles that of a sphere than that of the original core. By the method adopted it is claimed that the highest differences of electric potentials are found only upon the outside wires, and that the conditions are very favourable to the retention of insulation under varying circumstances. The action of the machine may be described by reference to Fig. 4, which shows the armature in skeleton. It will be noticed that the two opposite portions, A A, of the same coils, passing at the same instant before opposite poles, generate currents which combine, consequently the three coils may be considered as reduced to their three halves A, B, C. These are represented in Fig. 6 by three semicircles at angles of 120° from one another, the ends connected at *h* and to the commutator, as shown.

The brushes are placed diametrically opposite to each other and parallel to the line of maximum effect. By referring to Fig. 6 it will be seen that in such a position, A being situated in the neutral line, its corresponding segment will not be touched by the brushes and it will consequently be cut out of the circuit. At the same time B and C pass under opposite

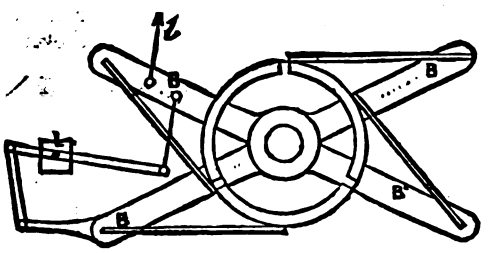

FIG. 12.—Brush Holder.

poles, communicate their current to the brushes, and are connected in series. When, on the contrary, A coincides with the maximum line, as shown in Fig. 7, B and C will pass under the same pole and one of the brushes will simultaneously touch the adjacent ends of their respective commutator segments. At this point B and C will momentarily be joined in parallel or quantity, and together they will be in series with A. An instant later (the armature turning in the direction of the arrow), B will be cut out of the circuit, and A and C united in series, which action is constantly repeated.

It will be noted that each coil is cut out of circuit the moment it traverses the region of smallest effect, but by means of the simple arrangement shown the cutting out of circuit of each coil takes place at the instant the latter reaches a point 60° from the neutral line; or, in other words, when it has reached a point at which it is no longer important to collect its current.

Prof. Thomson accomplished this at first by cutting the segments of his commutator so as to leave steps at the ends (Fig. 8), which lap over about 35°. In this way two adjacent coils, B and C for example (Fig. 7), remain in parallel while the armature passes over an arc of 35°, and the currents generated in B during that time are utilised. Another advantage of this arrangement consists in the fact that each brush comes in contact with a coil at the moment in which the latter becomes active, and does not leave it until it is almost completely inactive. The spark due to the extra current is consequently considerably diminished.

This form of commutator, although efficient, has been replaced by another, in which the segments terminate as usual in simple square ends. The same result is accomplished, however, by substituting two brushes instead of one. Both brushes of each pair are connected together, but the respective brushes are placed so as to touch the commutator at points 35° from each other, which arrangement is obviously equivalent to the first. Fig. 9 shows this in a very clear manner, the coils being

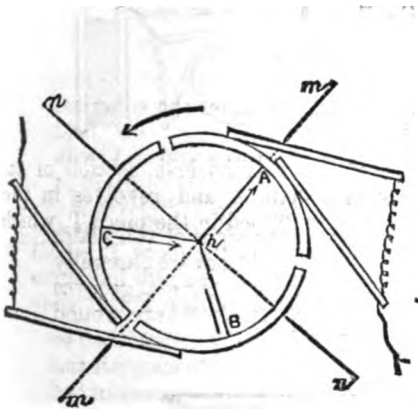

FIG. 9.

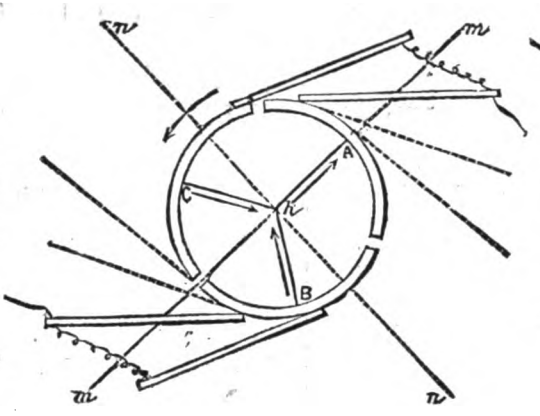

FIG. 10.

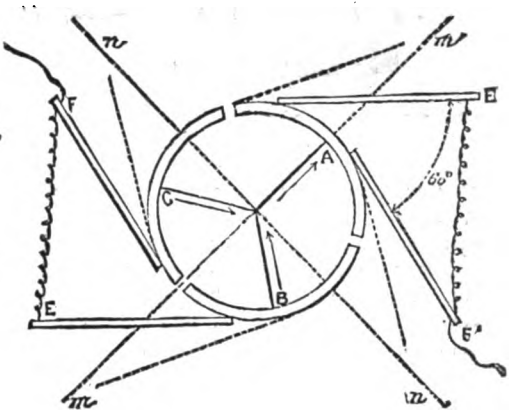

FIG. 11.

represented by three straight lines, intersecting the commutator segments. This figure also shows the neutral and maximum lines in their true position, designated respectively by *n n* and *m m*. In the position shown, it is easy to see that the arrangement maintains the coil B in circuit up to the point where it reaches the neutral line.

Prof. Thomson regulates the current of his machine by varying the position of the brushes with respect to the commutator, and he accomplishes this object in two ways.

The first method, which he terms *forward regulation*, is employed when a diminution of current is required, and consists simply in advancing the position of the brushes a certain distance on the commutator. By referring to Fig. 10 it will be seen that by this means the contact of each coil with the brushes is maintained even after it has passed the neutral line some distance. As the current generated in the coil after passing the neutral line is in an opposite direction, it follows that, being still in connection with the same brush, it will generate a counter electromotive force which will tend to diminish the total current. The second method mentioned is termed *backward regulation*, and is now generally used. Under normal conditions, the brushes in each pair form an angle of 60° between them, and touch the commutator at points also 60° apart, as shown in Fig. 11; consequently the angular distance between the first of one pair and the second of the other pair of brushes is 120°, *i.e.*, the length of one segment of the commutator. It is evident that with this arrangement none of the coils will be cut out of the circuit, since each segment of the commutator will have to pass from one pair of brushes to the other at the instant the coil itself is at the

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neutral line; thus there are always two coils in parallel, joined in series with a third.

When the machine is working normally the position of the brushes is that just shown; but when a reduction of the resistance in the external circuit necessitates a reduction of potential it is accomplished by a peculiar movement of the brushes. In order to accomplish the desired result the brushes F F' are given a retrograde motion, while at the same time the brushes E E' (Fig. 11) advance a distance three times as great as the former recede, as shown by the dotted lines.

The device employed for the purpose of effecting the differential movement of the brushes is shown in Fig. 12. The brush-holders B B are connected to those of B' B' by the lever L vibrating on a pivot so placed that the relative lengths of the lever arms are as 3 to 1.

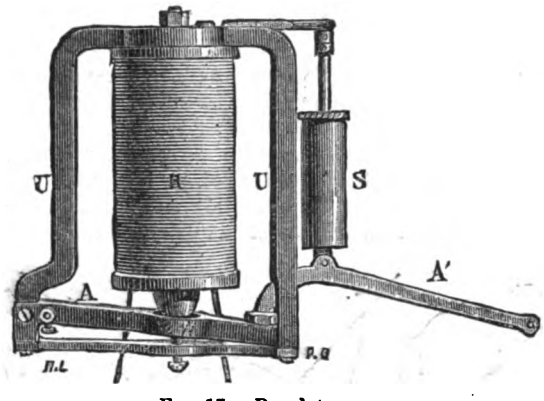

FIG. 13.—Regulator.

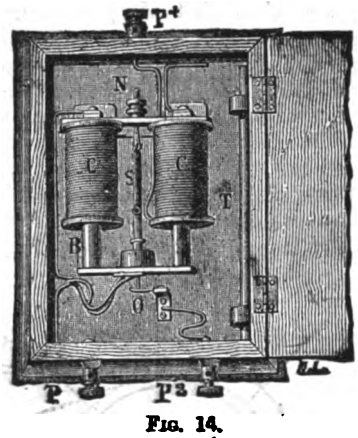

FIG. 14.

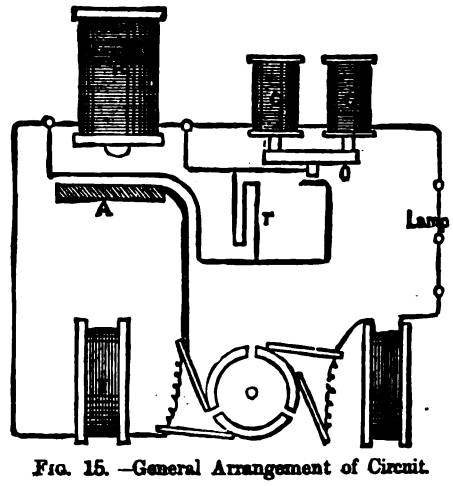

FIG. 15.—General Arrangement of Circuit.

This system of brushes is operated by a regulator-magnet, supported at one side on the frame of the machine as shown in Fig. 1. The regulator is shown in detail in Fig. 13, and consists of a U-shaped standard, U U, carrying the armature A at its lower end. The end of the core of the electro-magnet is in the shape of a parabola, and enters a corresponding cavity in the armature. The proportions are such that the attraction is constant for a given current in every position of the armature within the limits of its movement. The armature has a prolongation A' which transmits its motion to the brush holders by means of the rod *l* (Fig. 12). The dash pot S prevents any violent motion of the lever A'.

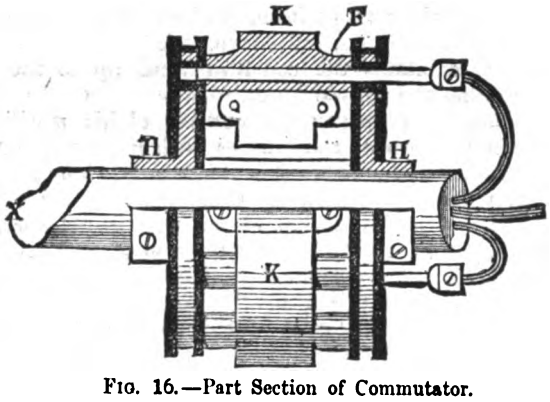

FIG. 16.—Part Section of Commutator.

If the main current were allowed to pass directly through the magnet R it would act as a regulator, but its action as such, would not be sensitive enough. For this reason the current is, in addition, passed through a pair of helices, C C (Fig. 14), the cores of which are suspended by a spring, S. When the current is of normal strength the cores rest upon a finger at O, which contact completes a shunt of no resistance around the electro-magnet R, and the latter consequently remains inoperative. If the current becomes too strong, however, the helices draw their cores upward and break the contact at O, which sends the current through R, and causes A to move the brushes accordingly. In order to prevent sparking at O, a carbon resistance, T, is shunted around it, as Fig. 15, which shows the arrangement of the entire circuit.

Prof. Thomson has introduced into his machine an ingenious device for the purpose of preventing the formation of such arc. He has found that in order to accomplish this a thin blast of air directed against the commutator suffices, and that it possesses the additional advantage of permitting the commutator to be freely oiled. Fig. 16 shows the commutator partly in section, while Fig. 17 illustrates the method of applying the air jets, the two nozzles B^3 B^3 being placed opposite to the ends of each forward brush. In the normal position of the brushes a small spark is produced at the ends of the commutator segments, against which the air blast is directed, preventing any injurious action on the former. The blower which furnishes the puffs of air is illustrated in detail in Fig. 18, which shows a transverse section of it. The hub D is mounted on the shaft X and revolves in the centre of an elliptical chamber contained in the piece T, which is supported by the frame of the machine. The hub has three radial slots in which the wings of hard rubber P P P slide

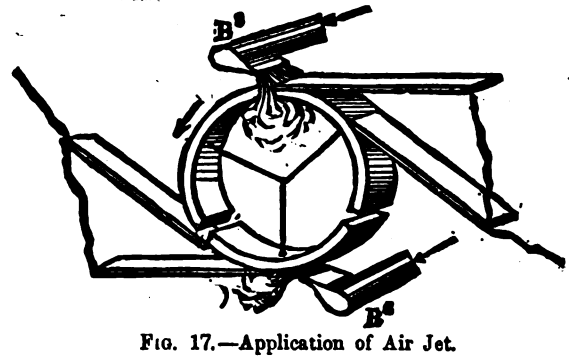

FIG. 17.—Application of Air Jet.

freely. During the rapid revolution of the axis the wings are kept against the sides of the oblong chamber and push the air before them, acting in the same manner as a rotary air-blower. O O are the air inlets and Z Z are the outlets, which

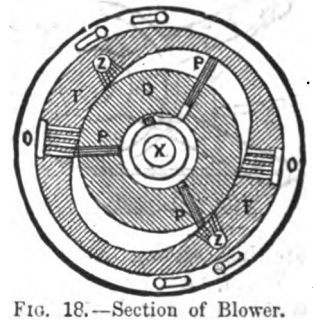

FIG. 18.—Section of Blower.

are connected to the nozzles above the commutator. The inlets are covered with wire gauze to prevent the entrance of dust particles, and the hub D is fixed on the shaft in such a position that the jet of air shall be strongest at the moment in which the edges of the commutator pass under the brushes.

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NOTES.

UNDERGROUND WIRES IN CHICAGO.—The work of placing the electric light, telegraph, and telephone wires underground in Chicago has begun in real earnest.

VENTILATION AND ELECTRICITY.—The restaurant Marguery, in the Boulevard Bonne-Nouvelle, in Paris, is about to be fitted up with 4 *punkahs*, put in motion by a Gramme motor.

PERSONAL.—We understand that Mr. Alexander Bernstein has taken up his residence in England in order to personally manage the newly-organised Bernstein Electric Lamp Company.

NOMINATION.—We are glad to hear that the distinction of the Légion d'Honneur has been conferred upon M. Lazare Weiller, the inventor of the now well-known bronze-silicium wires.

THE ELECTRIC LIGHTING ACT.—On Monday Baron Henry de Worms informed Mr. Warton that the Government had no present intention of proposing any amendment of the Electric Lighting Act, 1882.

LIGHTING OF A LARGE STEAMER.—The contract for electric lighting the large steamship "Algoma," recently launched by Messrs. J. L. Thompson and Sons, has been given to Messrs. Weedon and Irish, of Sunderland.

THE QUEENSLAND TELEGRAPHS.—The Government has been calling for tenders for a telegraph line to Cape York, with a view to an extension to Thursday Island. The length of the line to be constructed is about 400 miles.

PROPOSED ELECTRIC LIGHTING OF MOSCOW.—The Municipal Council of Moscow, in Russia, are making enquiries with a view to eliciting the best means to be adopted for the proper and efficient lighting by electricity of that town.

THE INTERNATIONAL TELEGRAPHS CONFERENCE.—A Rio de Janeiro telegram states that Señor Capanema has left for London on his way to Berlin, where he will represent Brazil at the International Telegraph Conference, which will meet on August 10.

COPPER MINING IN NEW ZEALAND.—The Nelson *Mail* states that news had been received that good copper had been struck in the Doctor's Lode, and in the Champion Lode in the Champion Company's mine, at points where it has not yet been found before.

NEW SIGNAL STATION.—A Lloyd's signal station is about to be established at Anaga Point, on the Island of Santa Cruz de Teneriffe. The station will be in telegraphic communication with this country by means of the cable recently laid connecting Teneriffe with Cadiz.

NEW CABLE.—The laying of a new telegraph cable between Aberdeen and the Shetland Islands was completed on Tuesday last by the cable ship "Monarch." The cable will be of great value in the development of the herring fishing industry, in which fast steamers are now employed.

LONG DISTANCE TELEPHONY.—The Van Rysselberghe system in Belgium has now been extended to Louvain, which is 30 kilometres (or 19 miles) distant from Brussels, and over 40 kilometres (or 25 miles) distant from Antwerp, the first centre that was connected with the capital.

ANNIVERSARY OF THE FIRST ATLANTIC CABLE.—To celebrate the twenty-seventh anniversary of the completion of the first Atlantic cable, Mr. Cyrus Field will give a dinner on 5th August, when the American Minister and many representatives of the telegraphic world will be present.

THE SWAN LAMP IN GERMANY.—We have received a telegram from Mr. C. H. Stearn, Berlin, announcing that the Appeal Court have revoked the injunction prohibiting Naglo Brothers from using Swan lamps. This injunction, it will be remembered, was granted by the inferior Court in Berlin.

APPOINTMENT.—The Swiss Federal Council at a recent meeting nominated M. Emile Eschbœcher, Chef de Bureau to the Minister of Posts and Telegraphs in France, to the office of Secretaire du Bureau Internationale des Administrations Télégraphiques, left vacant by the death of M. de St. Martial.

A NOVEL EXHIBITION.—An exhibition will be held in Lille, France, on the 6th of next September, of different apparatus, chiefly electrical, for the purpose of giving alarm in case of fire. An interesting feature of the exhibition will also be a number of the latest and most approved patterns of safety lamps.

THE ELECTRIC LIGHT AT ESHER.—The Prince of Wales honoured the Hon. H. Bourke by visiting Nelville House, Esher, on Saturday last. The beautiful and extensive grounds were most effectively illuminated for the garden *fête*, a remarkable effect being produced by the illumination of the entire lake by electric light.

TEMPORARY SUSPENSION OF THE TELEPHONE SYSTEM IN BERLIN.—During the thunderstorms of the 14th inst., the electrical disturbance of the atmosphere in Berlin had such an effect upon the telephone system that it was considered necessary to consult the safety of the officials by suspending the service until the storms were over.

UNDERGROUND WIRES IN BROOKLYN, U.S.A.—The following Commissioners of Electrical Subways for the City of Brooklyn have been appointed under the amended State law relating to the putting of telegraph and other electric wires underground :—Professor George W. Plympton and Messrs. Rossiter W. Raymond and John Reynolds.

THE CITY AND GUILDS OF LONDON INSTITUTE.—Prof. Ayrton, F.R.S., will give at the Central Institution, Exhibition-road, a course of lectures and laboratory instruction for technical teachers and others, on the "Teaching of Electrical Engineering," the course to commence on the 27th inst. Further particulars will be found in our advertisement columns.

UNIVERSITY COLLEGE, LONDON.—The Council of the University College, London, have instituted a Professorship of Electrical Engineering, and have appointed Dr. J. A. Fleming, who will retain his connection as advising electrician with the Edison and Swan Electric Light Company. The courses of lectures and demonstrations will commence in October.

A NEW VISUAL TELEGRAPH.—A new visual telegraph is now said to be in operation between Guadeloupe and La Martinique, by means of an intermediate station at Marie-Galante. The speed of transmission is about a minute and a half per word, and two operators are required at each instrument. A French contemporary *naïvely* remarks that the cost of the installation of the apparatus is less than that of a telegraphic cable.

THE CRUTO INCANDESCENT LAMP.—The principal feature in the Cruto incandescent lamp is the method employed to obtain perfect homogeneity of the filament. This is effected by depositing the carbon very gradually upon a core of platinum, about 0·0004 inch in diameter, raised to incandescence by the passage of a current while in the midst of a

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hydro-carbon gas. The result is a carbon of great density, the pores of which are infinitesimal.

THE LATE STORM IN THE METROPOLIS.—On Monday night the metropolis was visited by a storm of rain of an exceedingly violent description. About a quarter to nine o'clock rain began to descend smartly. The downpour increased in force about nine o'clock, and ultimately culminated in a violent storm. During the storm there were several very brilliant flashes of lightning, instantly followed by loud peals of thunder. No damage to life has, however, been reported.

CUBA SUBMARINE TELEGRAPH COMPANY.—At a meeting of the board of directors of this company, held on Wednesday, the audited accounts for the half year to June 30 were submitted, and it was resolved, after providing for the dividend on the preference shares and placing £3,500 to the reserve fund, to recommend the payment of a dividend on the ordinary shares at the rate of 10 per cent. per annum free of income tax, leaving £810 to be carried forward to the current half year's account.

NEW BRAZILIAN CABLE.—It is said that a contract has been concluded securing to the Central and South American Telegraph Company a concession to establish cables between Buenos Ayres and Rio de Janeiro; and land lines between Buenos Ayres and the Pacific side, thus securing to an American company continuous and independent telegraphic communication between the United States and Brazil. The necessary decree has been signed by the President of the Argentine Republic.

THE SUBMARINE TELEGRAPH CABLES BILL.—The Western Union Telegraph Company, the Commercial Cable Company, the Compagnie Français du Télégraphe de Paris à New York, and Siemens Brothers and Company have petitioned the House of Lords, praying to be heard by counsel against the Submarine Telegraph Cables Bill. This measure, which has for its object to carry into effect an International Convention for the protection of submarine cables, has already passed the House of Commons.

TELEGRAPHS ACTS (AMENDMENT) BILL.—On Monday last Lord John Manners, in reply to a question, said that his right hon. friend the Chancellor of the Exchequer would endeavour to find an opportunity for the consideration of this Bill, and when it reached committee stage he himself would propose some amendments. That would give the House a fair opportunity of dealing with the whole question. It was the hope of the Government that the measure would be passed into law this session. Mr. Shaw-Lefevre said that the course proposed by the right hon. gentleman was most satisfactory.

LIGHTING CONTRACT FOR BELGIUM.—The Belgian Minister for Railways, Posts, and Telegraphs announces that on Wednesday, 19th August, a ten years' contract will be let at the Brussels Bourse for lighting part of the Montigny station by gas or electricity. In the latter case the contractor will have to provide the building, motors, dynamos, leads, stores, labour, and all accessories, and maintain the same during the term of the contract. The Government reserves the right of taking over the installation at a price, decreasing each year, to be named in the tender.

A WONDERFUL BATTERY!—A story comes from San Francisco of a small bichromate of potassium cell, which is said to induce a current sufficient to overcome the resistance of over 5,000 miles of No. 10 galvanised iron wire. It is claimed that this invention will mark a new era in telegraphy, doing away with the huge batteries and dynamo machines now in use, and thus effecting a saving, as estimated, of £200,000 annually in America alone. It is a curious and interesting fact that, no matter how tin-pot the contrivance may be, it is always going to mark a new era or bring about a revolution in science. What do they burn, think you?

LONG DISTANCE TELEPHONY IN ENGLAND.—Experiments with the telephone of an important character were recently made by the officials of the Post Office, and the question whether oral communication between London and other distant centres of commerce is possible was placed beyond doubt, the result of the experiments being eminently satisfactory. The trial was made between Uxbridge, fifteen miles west of London, and Liverpool. The distance is 200 miles, and the tests satisfied the operators that it is possible to communicate between centres twice that distance apart, a return wire being used in this instance. The articulation was very distinct.

ANOTHER INDUCTION TELEGRAPH.—We are informed that Mr. Edison and others have invented a plan by which telegraphic communication between moving trains and also between the trains and various stations along the road can be carried on successfully. This consists of a canvas covered copper foil along the sides of the cars. By this means, it is said, messages can be taken from the wires, as they are now strung from forty to sixty feet from the train. The foil can be painted so as to be entirely hidden from view and will operate as well as if exposed to the air. This is probably identical with the system already noticed in our columns.

THE GLOBE TELEGRAPH AND TRUST COMPANY.—The directors of this company at the board meeting held on the 7th inst. decided to recommend the payment of a final dividend on and after the 28th inst. of 3s. per share on the preference shares, less income tax, and of 3s. per share on the ordinary shares (income tax having already been deducted), making, with the former distributions, a total dividend of 6 per cent. on the preference shares, and 4½ per cent. on the ordinary shares for the financial year ending the 18th inst., carrying forward a balance of £1,791. 15s. 5d. The transfer books were ordered to be closed from the 20th to the 28th inst., both days inclusive.

LAW AND ELECTRICITY.—Mr. J. H. A. Macdonald, Dean of Faculty, Q.C., lately appointed Lord Advocate for Scotland, is one of the most distinguished associates of the Society of Telegraph-Engineers and Electricians. His versatility has manifested itself both in his inventions and in his contributions to literature, which have been of a varied character. A few years ago he invented a holophote course indicator for the prevention of collisions at sea, and for this he received a bronze medal from the jury of the International Electrical Exhibition at Sydenham in 1882, and in the same year a certificate of honourable mention from the Exhibition of Means for Protecting and Preserving Human Life.

THE TELEPHONE IN AMERICA.—The total number of telephone exchanges in existence in America on 1st January, 1885, was 772. The number of miles of wire in use, 101,734, and of *employés*, 5,168. The subscribers amounted to 134,847. The increase in the number of subscribers during the year 1884 was 11,222. The annual subscriptions in different parts of the country are as follows:—In New York, £30; in Cincinnati, £35; Boston, £25; Baltimore, £25; Philadelphia, £25; New Orleans, £25; St. Louis, £25; and Chicago, £26. Against these the charges in some other parts of the world may be cited, such for instance as Paris, £24; Melbourne, £20; Sydney, £20; Moscow, £25; and St. Petersburg, £25.

PHOTOGRAPHS OF LIGHTNING.—Photographs of flashes of lightning have lately been obtained by Dr. Kayser, and he

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has communicated the results of his experiments to the Berlin Academy. The lightning is shown to have proceeded very often from one point to several points, the aspect in the photograph being like that of a river with numerous branches. It was noticed that the feebler lightning flashes did not radiate in this manner. In one instance the stem did not only consist of one bright line, but of four lines parallel throughout, the second being like a band stratified transversely. Dr. Kayser explains this effect owing to the oscillating discharge, though he cannot assign any reason for the stratified appearance of the band.

THE TELEGRAPHS BILL.—The secretary of the Manchester Chamber of Commerce has written as follows to the *Manchester Courier*:—In answer to sundry inquiries at this chamber, perhaps you will allow me to say that on receipt of the news of the possible dropping of the Bill providing for so-called sixpenny telegrams, which was read a second time on the 22nd May, the president of the chamber (Mr. J. F. Hutton) addressed a letter to the Postmaster-General urging the great importance of reconsidering his decision, and expressing the earnest hope of the directors of the chamber that the Bill might be permitted to pass on to the committee stage without delay. So far no reply has been received to Mr. Hutton's letter.

THE TORPEDO SCARE.—Admiral Hobart Pasha, who seems to know what he is writing about, has recently published a pamphlet upon the use of torpedoes, both for purposes of attack and of defence. During the course of his remarks he says:—"I have visited the really wonderful establishment of Messrs. Latimer Clark and Co. There I saw every sort of invention in torpedo mines for coast defence. What astonished me was their simplicity, their cheapness, and so far as I could judge, their efficiency. The principal thing that struck me was the system they propose to adopt for laying down their ground mines. Simplicity, safety from accident, tremendous powers of local offence and defence, were clearly demonstrated in what I saw at these interesting works."

TELEPHONE RATES IN MANCHESTER.—A deputation of subscribers recently waited upon the directors of the Lancashire and Cheshire Telephonic Exchange Company at the head office in Manchester for the purpose of urging that the present rental rate of £20 should be reduced. Having heard the views of the deputation, Mr. C. Moseley, the chairman of the directors, replied at length to statements which had been made upon the subject in letters to the newspapers. He intimated that, in justice to the shareholders, the directors could not, under existing arrangements, reduce the rate, but that a new method of manipulation was under consideration which, if it stood the tests about to be applied to it, might lead to a reduced charge under certain conditions.

BOOKS RECEIVED.—"Second Edition of the International Inventions Exhibition Official Catalogue," including in the introductory portion a full section in connection with the electric lighting, and Sir Francis Bolton's description of the fountains and illuminations; and in the catalogue proper detailed descriptions of the Austro-Hungarian and other sections. A noteworthy feature of this edition is the exhaustive subject index, which will greatly facilitate reference to the exhibits.—"Minutes of the Proceedings of the Institution of Civil Engineers."—"The Journal of the Society of Telegraph Engineers and Electricians," No. 57, Vol. XIV.—"Hanbuch der Elektrotechnik," Bearbeitet von Dr. Erasmus Kittler, of Professor un der Grossherzogl, Technischen Hochshule in Darmstadt.

THE ELECTRIC LIGHT AT AN "AT HOME."—At the "At home" given by Mr. Thos. Cordes, M.P., at Hill-street, Berkeley-square, on the 9th inst., Messrs. A. R. Sennett and Co. temporarily installed the electric light; upwards of 100 lamps being employed. The spaces lighted comprised the grand staircase (by means of a large electrolier and lamps hung upon tree ferns), the two drawing rooms (by means of lamps placed on the cornices, glasses, curtains, &c.), the great ball room (by means of a very large crystal electrolier), and dining room. In the latter case the lighting was effected entirely by means of a number of 10 candle-power lamps, supported by the flowers used for the decoration of the supper tables. The electric lighting was much admired, and gave great satisfaction.

PROPERLY PUNISHED.—At a recent church festival at Cotopaxi, Mexico, a band of thieves conspired to extinguish the electric lights in the cathedral, and take advantage of the confusion and darkness to rob the people assembled there. The leader of the gang threw a wire over the electric light wire with the intention of drawing it down. As the ingenious but insufficiently-informed gentleman was not acquainted with the nature of shunt circuits the result must have somewhat surprised him. A sufficient amount of the current passed through his body to kill him instantly, while the members of the gang made good their escape in the confusion caused by the tragic death of their leader.

ELECTRIC LIGHTING IN THE CITY.—At a meeting of the City Commissioners of Sewers at Guildhall, on Tuesday afternoon, Mr. J. V. Moore moved "That, having regard to the repeated failures of private companies to supply electricity, it is desirable that the Commission do undertake street-lighting by electricity, and that it be referred to the Streets Committee to select a small area and to obtain estimates of costs of installation." He said that when they considered that the electric light was a success in many places, it was greatly to be regretted that in the city they should be without the light. The Commission were the lighting authority of the city, and had ample powers and means to carry out any system they might adopt. An experiment would not cost more than £1,500. After some discussion an amendment was moved by Mr. Deputy Ashby, and accepted by Mr. Moore, by which the whole matter was referred generally to the Streets Committee to inquire into and report.

BECHUANALAND.—The revenue from the new territory, derivable from the Cape Customs, an Imperial contribution, the police allowance, the land receipts, the hut tax, and stamps, is £63,000, and the expenditure is estimated at £62,000. Provision will be made for the official establishments and legislative expenses, as well as telegraphs, and interest on a loan of £36,000 for public works. The latest news, according to a contemporary, from the Telegraph Section in Bechuanaland, is that Major Jelf, R.E., Director of Military Telegraphs, has returned from a tour of inspection along the existing line, and has brought up with him stores for 300 miles more if required. The line will at once be run up to Kanya and Monopolole, and possibly eventually to Shoshong, the capital of Khama's country, and within measurable distance of the Zambesi. Lieut. Anstruther, R.E., remains at Mafeking in charge of the portion of line, Mafeking to Vryburg, and Sergeant-Major Cole, R.E., of the southernmost portion, Vryburg to Barkly.

THE AMET ELECTRIC GOVERNOR.—According to an American contemporary a modification of the Amet electric governor for the purpose of regulating the currents produced by dynamo electric generators has recently been perfected. The need of this device in cases where two or more dynamos are driven

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from one source of power is self-evident, as the steam governor can control but one dynamo or one series of dynamos on a single circuit, as it controls by varying the speed to suit the amount of current required. Mr. Amet calls his device a brush regulator, and where it is used the speed is kept constant and the point of delivery on the generator changed to compensate for any and all changes in the resistance to be overcome. As demonstrated by the tests, a dynamo may be short-circuited at full speed without injury to the machine, and any number of lamps may be thrown in or out of circuit. The apparatus steadies the lamps, and does away with about 20 per cent. of the flickering, the lamps remaining at a normal brilliancy whether two or twenty are burning. A constant current is maintained, and all changes are instantaneously compensated for.

Trials Made at Turin and at Lanzo on the Distribution of Electric Light to Great Distances.—According to the *Proceedings* of the Institution of Civil Engineers, an electrical Exhibition has been held at Turin, and important prizes have been offered by the Italian Government and by the City, of which the following facts have been communicated to the academy by M. H. Tresca :—Messrs. Gaulard and Gibbs have established between the Exhibition, the station at Lanzo and intermediate stations, a circuit of 80 kilometres length, with a chrome-bronze wire, of 3·7 millimetres diameter. This wire is traversed by alternating currents produced by a Siemens machine of 30 horse-power. The following lights were worked from the circuit with the intervention of Messrs. Gaulard and Gibbs' secondary or induction apparatus; at the Exhibition, 9 Bernstein lamps, 1 Soleil lamp, 1 Siemens lamp, 9 Swan lamps, and 5 other Bernstein lamps at a short distance, all, however, needing very different electromotive forces. At the station of Turin-Lanzo, 10 kilometres distant, 34 Edison lamps of 16 candles, 48 of 8 candles, and a Siemens arc lamp. Later there were added at the station at Lanzo, 40 kilometres distant, 24 Swan lamps of 100 volts. The lighting was perfectly regular, and easily independently extinguished and illuminated.

The Telephone and Fires.—On the 12th inst. a fire broke out in the warehouse premises of Messrs. Spicer and Co., in John-street West, Blackfriars-road, and eventually completely destroyed a five-floored warehouse, used for various purposes, besides causing other damage. Intimation of the outbreak was conveyed to the head-quarters of the Metropolitan Fire Brigade in Southwark Bridge-road. On the arrival of the steamer it was found that a very strong fire was already raging on the premises. Superintendent Hamlyn, when he arrived from Kennington, saw the serious nature of the fire, and telephoned for engines, which arrived in rapid succession from Waterloo road, Tooley-street, Old Kent-road, Peckham, Brixton, Clapham, Chandos-street, and other stations. In the course of half an hour, by means of the rapid circulation of the alarm, there were eight steamers pouring water from different points upon the fire. An outbreak of a most destructive character also took place on Monday among the property of Messrs, Smith and Co., timber merchants, &c., No. 11 Arch, Howley-place, Belvedere-road, Lambeth. The alarm quickly spread, communication with the Telephone Exchange being effected through the firm of Mr. J. S. Gabriel, Nos. 67 and 69, Belvedere-road, causing it to be "switched on" to head-quarters, Southwark Bridge-road. A strong force of the members of the Metropolitan Fire Brigade was prompt in response to the summons, and steamers from head-quarters, Kennington-lane, Tooley-street, Camberwell, Rotherhithe, Old Kent-road, &c., attended,

The Earthquakes.—A Reuter's telegram, dated Simla, July 9, announces that shocks of earthquake continue to be felt in Cashmere at intervals of two or three days. A severe shock occurred at Srinagar on the 4th inst. A telegram from Calcutta on Tuesday last announces that a smart earthquake shock was felt there at 6:25 a.m. The houses rocked violently for several seconds. A sharp shock of earthquake, accompanied by a loud rumbling noise, was felt at Kopreinitz in Styria on the night of June 28, which was followed by two others the following morning. Several houses were thrown down and other damage done. A new theory as to the origin and cause of earthquakes has, says *Nature*, been propounded by the Viceroy of the Chinese provinces of Shensi and Kansu. In a recent memorial to the throne, published in the *Peking Gazette*, this high official describes an earthquake which occurred on January 15 in various parts of Kansu, and summarises briefly the various reports which he has received on the subject relating to the motion, the damage done (which in some places was extensive), and the measures taken for the relief of the sufferers. He then proceeds to say that for years past earthquake shocks have been so frequent in these regions that people have grown quite accustomed to them; indeed, one officer informs him that in certain villages there were indications of a movement of the earth every night during the fourth watch, but these always ceased after a heavy fall of snow. The memorialist concludes by attributing the earthquake to the mildness of the winter, which caused an excess of the *yang*, or male element of Nature; "but it was due in a measure also to the perfunctory performance of their public duties by the local officials, who thereby failed to call down the harmonising influence of Heaven, and the memorialist can only endeavour to remedy this fault by encouraging his subordinates to cultivate habits of introspection and examination of their own shortcomings, himself setting the example." A shock of earthquake occurred at Valez-Malaga on Monday night, but no damage was caused. A smart shock of earthquake also occurred at Smyrna at half-past 1 o'clock on morning of the 15th inst. The vibration was also slightly felt at Chesmé.

Electric Light Applied to Firearms.—Last week we recorded the application of a miniature electric lamp to the front sight of a rifle; and now intelligence reaches us of the same idea having been worked out independently in France, while a lamp of greater power, intensified by a projector, has been fitted to the end of the muzzle, for throwing a strong light on the object aimed at, the light only being shown at the moment of firing, through contact being made by the pressure of the butt end of the piece against the shoulder. These two inventions, by M. Gustave Trouvé, of Paris, formed the subject of a communication to the French Academy of Science on Monday, July 6. The luminous fore sight, no larger than an ordinary metallic sight, consists of a fine platinum wire, enclosed in a glass tube, which is protected by a metal case having a slit opposite the back sight, so that, when contact is made, the luminous line is only visible by the person aiming, while the light is not sufficiently powerful to give out lateral rays perceptible to the enemy, for instance. The current for the lamp is supplied by a bi-sulphate of mercury battery, no larger than the finger, attached to the barrel by two india rubber bands, while the leads are put in connection with the poles by elastic clips. The battery consists of a cylindrical ebonite cell, with a zinc and carbon couple occupying the upper half, and diluted sulphate of mercury the lower, so that it only comes into action when the piece is levelled for firing. For throwing a strong light on the object aimed at—and this application is more especially

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useful in war for repelling night attacks—a Hélot-Trouvé projector is attached to the muzzle of the rifle by india rubber bands. The projector, such as is used for surgical purposes and for throwing a strong light on objects for the microscope, consists of a tube, carrying in the middle an incandescent lamp with a single straight filament, while at the back is a reflecting mirror, and at the front a condensing lens with adjustment. A small bichromate of potash battery is carried by the belt or the cross belt, and a metallic contact is fitted to the butt end of the piece, so that the light is projected only at the moment of firing. At the same time the projector furnishes a safe lamp for entering powder magazines, &c.

THE ELECTROLYTIC REDUCTION OF FINE COPPER FROM ITS ORES.—The Italian Copper Mining and Electro-metallurgical Company, of Genoa, has received the second prize of 5,000 lire, and the process which has been adopted for some time past at their works at Casarza, near Sestri-Ponente, is described in the *Proceedings* of the Institution of Civil Engineers, as follows :—The plant includes twenty Siemens electrolytic dynamos, giving a current of 250 amperes, at 15 volts tension, each of which serves twelve reducing baths. Part of the ore, varying in amount according to circumstances, is smelted to a coarse metal, containing copper 30, sulphur 30, and iron 40 per cent., which serves as the anode. Another part of the ore is roasted and lixiviated to form a solution containing as much copper sulphate as is required to render the ferrous sulphate of the anode useful for the electrolytic decomposition of the copper salt. The order of the operation is as follows :—Preparation of the anodes : The ore intended for this purpose is smelted for coarse regulus in the usual way. The regulus is cast into thin slabs, a strip of copper being placed in the mould to form the conductor for the current. The anodes so prepared are placed in the decompositing cells, thin sheets of copper being used as cathodes.—Preparation of the solution : The ore roasted so as to produce the necessary sulphate for the bath is systematically lixiviated with an addition of sulphuric acid to dissolve any oxide of copper formed in roasting the liquor, containing copper and iron sulphate, is kept in tanks and added to the bath as required. The copper sulphate is decomposed by the electric current, copper being deposited on the cathode, while the anode is attacked with the formation of iron salts and sulphuric acid, which prevents the deposit of iron and the evolution of hydrogen, so that the copper deposits in a compact and chemically pure form. The saturation and proper composition of the solution is maintained by connecting the baths by pipes with the lixiviating vats, so that a constant and regular circulation of the liquor is kept up. The solution has a sufficient oxidising power to dissolve up metallic sulphides, in some cases without requiring a preliminary roasting. The greater part of the electromotive force necessary for the decomposition of the copper sulphate is furnished by the oxidation of iron in the anode, so that for the remaining work in the bath an electromotive force not exceeding one volt is sufficent. The exhausted anode may be utilised for the reproduction of sulphur or sulphuric acid. When the solution is overloaded with iron vitriol it is removed from the bath, and the last traces of copper are recovered by precipitation with sulphuretted hydrogen, which is produced by adding regulus to the acid liquor. At the same time the iron salts are reduced to ferrous sulphate, and the free sulphuric acid is neutralised. The iron vitriol may be recovered by crystallising, otherwise the liquors containing it, when freed from copper, are run to waste. If the baths are properly arranged, and care be taken to keep the liquors in circulation at the proper strength, a maximum yield of 44lb. of copper per horse-power employed may be obtained daily. The process appears to be particularly well adapted for mines in mountain districts where water-power is readily obtainable, but which, owing to the difficulty of obtaining, and the high cost of mineral fuel, are unfavourably placed for smelting operations.

THE TELEPHONE AT LIEGE.—A public meeting has been held at Liége, Belgium, under the auspices of the Chamber of Commerce, to support the application of M. de Locht, for a Government concession for establishing a telephone exchange in opposition to the Bell Company. The De Locht telephone was adopted for the first exchange at Buenos Ayres, but was replaced by the Bell telephone, in the same way that the Bell Company have absorbed the Gower telephone in Brussels and the Bède telephone in Liége. M. de Locht offers generally a reduction of 50 per cent. in the subscriptions, as compared with those at present maintained by the Bell Company, which has the monopoly. He proposes, within a radius of 2½ kilometres or 1½ mile, a fixed subscription of 50 francs or £2 per annum, with a tax of 15 centimes or three-halfpence per call up to 500, and 10 centimes or 1d. for every call above that number up to 2,500, after which there would be no tax. Beyond the radius named, the additional subscription would be 25 francs (£1) per kilometre (0·62 mile) per annum, so that for a distance of 10 kilometres or 6 miles, the annual subscription with the maximum number of calls would only amount to 390 francs (£15. 12s.) against 600 francs (£24) asked by the Bell Company. It came out in the discussion that the present Minister of Railways, Posts, and Telegraphs was opposed to competition—that he feared it would ruin the present company, some shares in which, it appeared, were held by members of the department. A resolution was passed unanimously, pledging the meeting to support M. de Locht's application. On Tuesday last week the subject was brought before the Chamber by M. Hanssens, who said that the question was one of public interest, but the Minister appeared to throw every obstacle in the way of any competition with the Bell Company. M. Vandenbeereboom, Minister of Railways, Posts, and Telegraphs, said that numerous petitions had been addressed to the Chamber in support of M. de Locht's application for a telephone concession in opposition to the Bell Company, all based on the principle of the liberty of competition. M. de Locht promised a reduction in the subscription, which should have its due weight, but the organisation, and indeed the existence of the service, must be taken into consideration. Experience had proved that a multiplicity of concessions brought about a complete disorganisation of the telephone service. Scarcely three years ago there were three companies in Brussels, and two each at Antwerp and Liége, which, after a hard struggle, had to combine with a considerable increase in the subscriptions. It was now acknowledged that to ensure a good service there should be only one telephone company, as everywhere, after a forced lowering of rates, resulting from ruinous competition, there was a considerable increase. When the Government came into possession of the telephone system, which it had the right to assume in seven years it would have to undo all that was not according to system, at great expense, which would necessarily increase the subscriptions, and all the more so as each system was incorporated in the scheme of long distance telephony. M. Somzée said that if the telephone companies retained the monopoly the country would not get the full benefit of the invention on account of the high rates of subscription. He was in favour of the taking over of all the telephone lines by the State. Ultimately the petition was referred to the Ministry of Railways, Posts, and Telegraphs.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 135.)

The Principle of Thermal Resistance.

Suppose we, with a sure faith in the truth of the principle of Conservation of Energy, and a knowledge of the equivalence of work and heat, observe that the motion of a magnet in the neighbourhood of a closed circuit generates heat in it, that this ceases when the motion ceases, and that we satisfy ourselves that this heat is the only final result of the motion, so far as energy is concerned. This heat must be the equivalent of work done. As we have no reason to suppose that the magnet is in a different state at the end from what is was in at the beginning of the motion, we cannot attribute the heat to a loss of potential energy by the magnet. Hence we may conclude that the heat is the equivalent of work done against resistance to the motion of the magnet. That is to say, however the magnet move, its motion is resisted. Here we have Lenz's law, without any reference to the direction of the current induced in the circuit, but merely as regards conservation. In fact we made no mention of current. If now we bring in other knowledge, that there is a current induced in the circuit, the heat being proportional to the square of its strength, we are still left without means of determining its direction in a given case. Only finally, when we utilise Ampère's determination of the mutual forces between magnets and currents can we exactly say in which direction the induced current will be in a given case, for it must always be such as to resist the motion.

Lenz's law is not, however, the subject of the present section, but is used to point out the distinction between the above kind of resistance to motion and the kind involved in the Principle of Thermal Resistance, to which we now proceed. It is such a large subject, and there are so many ways of treating it, that it is difficult to know how to begin; after consideration I adopt a method which I have not met with, and which is therefore, if not novel, at least unusual; believing that, whether it be better or worse than other methods, there is advantage in viewing a truth from all possible sides, to allow another law, that of the survival of the fittest, which, like that of thermal resistance, results from averages, to have a chance of operating.

We cannot, in general, alter the configuration of a body without doing work upon it, or letting the body do work. Considering any solid elastic body, for example, a straight wire: we cannot twist it without doing work. The motion is therefore resisted. On the other hand, if we let the wire untwist it can do work itself against external resistance. Here, of course, we must have conservation of energy when all actions are taken into account, and nothing novel so far is presented. But there is, during the changes of configuration of an elastic body, another kind of resistance brought into play, depending upon the rate of change of configuration, at least, usually. Suppose we twist a wire slowly, and at every stage of the process note exactly the amount of the applied force, or do the same by small instalments. By summation we know the total work done in producing a given twist. Similarly, if we let the wire untwist slowly by small instalments, the force will be the same in the same configuration as during the twisting, and the same amount of work will be done by the body. But if we twist the wire *suddenly* to the same extent as before *more* work will have to be done, or there will be an additional resistance to the motion at every moment, and if the wire suddenly untwist, it will do *less* work, or again, there is a resistance to the motion which did not exist before.

We may put it this way: If we measure statically the forces in different configurations we do not by summation get the total work done. There is always an additional resistance to the motion, opposing the change of configuration, never assisting it. I call this thermal resistance, because, whenever it occurs, there is a thermal effect also produced. It is not, however, necessarily a heating, as one might expect, but may be either a heating or a cooling. But, whichever it be, the change of configuration is always resisted. That is the cardinal fact that must be remembered.

If, during the change of configuration, the body be allowed to part with or to receive heat so as to neutralise the thermal effect if it be a heating or a cooling respectively (as by conducting the operation very slowly, and not thermally insulating the body), the thermal resistance itself is evanescent. On the other hand, if the body be thermally insulated, so that heat cannot leave or enter it, it will be of the full amount. This will serve to elucidate the effect above mentioned of *suddenly* changing the configuration. We thus give no time for heat to escape or be taken in appreciably. Now given this law, or principle of thermal resistance, and a statement of one effect upon a body, deduce another. I give a few examples.

(1). We observe that heat lengthens and cold shortens a bar. What should be the thermal effect of suddenly stretching it? It must be such as to oppose the stretching; that is, to shorten the bar, and is therefore a cooling.

(2). What should be the effect of removing the stretching force? To oppose the return to the unstretched length, therefore to lengthen the bar; therefore a heating.

(3). Water above 4° C. expands by heating, what is the effect of compression? Such as to oppose the compression; therefore a heating.

[Notice there are two effects—the thermal resistance and the heating or cooling effect.]

(4). Water below 4° C. contracts by heating. The effect of compression is, therefore, to cool it, as the compression is thereby resisted.

(5). Water expands in vaporising. Hence pressure raises the boiling point.

(6). Water expands in freezing. Hence pressure lowers the freezing point.

(7). An india rubber band at ordinary temperatures, stretched by a weight, lifts it when heated. What should result from suddenly stretching the band? The motion must be resisted; that is the invariable fact. The thermal effect is therefore a heating, for that, by the previous, lifts a weight.

(8). A twisted wire is suddenly twisted further. Is it a heating or a cooling effect that is produced? Whichever it be it must increase the torsional rigidity, so as to oppose the twisting. If, then, heat lessens the torsional rigidity, it is a cooling effect, and conversely.

(9). Compressing a gas heats it. Hence heat applied to a gas increases its pressure, for this is the only way to make the compression be additionally resisted. This property of a gas is so well-known that it is more difficult to recognise the principle. It is hard to imagine the possibility of a gas being cooled, by compression. Yet the principle involved is identically the same as in the less obvious illustrations.

Other mechanical illustrations may be multiplied indefinitely, but the above will be sufficient. When we wish to go further, and make applications to electricity or magnetism, it is necessary to be very particular that the necessary conditions are complied with. The thermal resisting force is always opposed to the motion, and so far resembles a frictional force; but the thermal effect, unlike that of friction, is reversible with the direction of motion, and the motion produced by heat is reversed if cold be applied. Thus, during the stretching of a spring, the pull of the spring is $F+f$, if F be what it would be if there were no thermal effect, and f is the small increase produced by, or accompanying it. On the other hand, when the spring shortens, the strength of force is $F-f$ at a corresponding stage, and at the same temperature, f being the same quantity as before. Regarding the forces as vectors, F is constant in direction, f changes, being with F in the stretching, and against it in the unstretching. That is, it is always against the direction of motion. The heat effect, if it be a cooling during the stretching, is a heating during the unstretching. And as regards the effect of heat, if heating increases, cooling must decrease the elasticity. If in some peculiar state, both heating and cooling produced the same effect on the elasticity, or if either stretching or unstretching produced the same thermal effect, we could not

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immediately apply the principle without reservation. Further investigation would be needed.

(10). Given a circuit of two metals A and B, at one temperature initially. We observe that slightly heating one junction causes a current from A to B, and cooling it causes a current from B to A. Here is a perfectly reversible thermal effect, although accompanied by other strictly irreversible effects in the circuit. In accordance with the principle, what should be the thermal effect at the same junction on passing a current from an external source from A to B? The current must be made weaker than it would otherwise be, hence the current due to the thermal effect is from B to A, hence it is a cooling, by the previous knowledge. At the other junction it must be a heating, for the current is there from A to B. Thus there is a transfer of heat from the first junction to the second. Notice the peculiarity that the thermoelectric force in the circuit, due to both junctions weakens the main current; that is the first conclusion. But the E.M.F. at both junctions is from A to B, whence it follows that at the first junction the E.M.F. is weaker than at the second. Further inquiries would lead us to the full theory of thermo-electricity.

(11). Given that the capacity of a condenser is increased by heating and decreased by cooling the dielectric, what should be the thermal effect of suddenly charging it? The charging must be opposed, hence a decrease of capacity or a cooling effect. Similarly, suddenly discharging the condenser should produce a heating effect, which we may conclude thus:—The discharge must be resisted. Now, the rate of discharge depends upon the difference of potential of the ends of the discharge wire. This must be reduced therefore. But a reduction of potential with the same charge means an increase of capacity, for which there must be, by the above, a heating effect. Observe here that these thermal effects are independent of the absorption phenomenon.

(12). A curious result of thermal resistance is that a perfectly elastic solid, if such really existed, vibrating, would come to rest without any external or internal friction to cause it. Thus in a vibrating spring, thermal resistance opposes its motion whether it be moving to or from the equilibrium position. Now, if the spring could give out and take in heat instantaneously, so as to keep its temperature constant, the effect would vanish, and, without friction, the spring go on for ever. Similarly, if the spring could be thermally insulated, the cooling and heating effects produced when moving to or from the equilibrium position would balance, and the spring could go on for ever. But practically, neither one nor the other condition can be complied with, and the spring must be brought to rest without friction entirely by the thermal effect being practically radiated or conducted away in one motion, without an exactly counterbalancing receipt of heat in the opposite motion.

There is another way of looking at the principle which is useful, viz., to direct attention to the flow of heat into or out of the body when it is being strained, supposing that the body is, in the first place, in thermal equilibrium with its environment, and that it can receive or lose heat instantaneously. Thus, in example (9), compressing a gas drives heat out of it. Now, go to the other end of the operation. Take heat out of a gas. It compresses itself. Or take example (1). Stretching a bar draws heat into it, and sending heat into a bar makes it stretch itself. From this point of view we regard two events as being invariably connected, motion of matter of a certain type, and a flow of heat in a certain way. But the method is less general than the preceding, assuming, as it does, that the flow of heat is always permitted, likewise the motion.

In all cases whatever in which the principle of thermal resistance has been experimentally tested, it has been found to be correctly followed by Nature. Can we then assert its invariable truth, and apply the principle unhesitatingly to hitherto unverified cases, possibly unverifiable? Is it possible to give a rigid demonstration of its truth? The first question may be answered in the affirmative, the latter not. We cannot prove it even as we prove the truth of conservation of energy, viz., by seeing that it is a necessary truth in pure dynamics, and extending our notions to all the operations of nature, observing that it is experimentally true in a great many cases, convincing ourselves of its universal application with the assistance of a little faith. For we cannot deduce the principle of thermal resistance from the laws of dynamics. It would be no breach of conservation of energy were it to be exactly reversed, were strains to be assisted by thermal effects. All we can really do is to convince ourselves that, being true in all observed cases, and its negation leading to extraordinary consequences which are *not* observed, though not dynamically impossible *à priori*, it must, by faith, be generally true.

First, put the principle in a mathematical form. Let an elastic body be strained from one configuration to another, keeping it always at one temperature t, to allow which a quantity of heat H leaves the body, whilst W is the work done upon the body. Then the principle asserts simply that $d\mathrm{W}/dt \div \mathrm{H}$ is positive, or that $d\mathrm{W}/dt$ and H are either both positive or both negative, which is easily verified by the above examples. More work is caused to be done by the thermal effect if it be not than if it be allowed to escape.

Next, to see the consequences of its negation, follow the example of the founder of thermodynamics, Sadi Carnot, wher, in the most masterly and scientific manner, he set to work to find the cause of the motive power of heat. After the above strain, bring the body back exactly to its original state through the same series of intermediate configurations, but at a slightly different temperature $t+dt$. This requires there to be two other operations (2nd and 4th), viz., to raise the temperature by dt in the second configuration, and to lower it by dt when it has got back to the first. Now the body does work $\mathrm{W}+\frac{d\mathrm{W}}{dt}dt$ at the higher temperature. Hence, in the complete cycle, the body does work $\frac{d\mathrm{W}}{dt}dt$. What else happens is that an amount of heat H is lowered in temperature by the amount dt. Now, without any experience to guide us, H and $d\mathrm{W}/dt$ may be algebraically positive or negative, and not of the same sign necessarily. But if they could be of opposite signs, work would be obtained through a substance *raising* the temperature of heat. If then we take it as axiomatic that it is impossible by conveying heat from a cold to a hot body to obtain mechanical effect, then we prove that the law of thermal resistance is universally true, at least for bodies in mass, and inanimate.

Now this axiom, so called, is really the principle Carnot was led to, viz., work is derived from heat by *lowering* its temperature. Carnot's principle is thus a consequence of the principle of thermal resistance. In Carnot's cycle for a gas engine heat is taken in at a higher and given out at a lower temperature, and the pressure is greater at the higher than at the lower, so that the gas does more work in expanding than in being compressed back to its original state, and thus we have finally heat lowered in temperature, and work done by the gas. In his water and vapour cycle it is similar, so he concluded that the necessary condition of obtaining work by thermal agency was the lowering the temperature of heat. He was only wrong as regards the *quantity* of heat lowered in temperature.

Now this being a consequence of the principle of thermal resistance, and the various examples above given being commonly regarded as consequences of the Second Law of Thermodynamics, with which Carnot was most assuredly not acquainted, how is it that Carnot was acquainted with *them*? I do not say he thought of them all. But he knew some of them, and, had he been asked what would be the result in a given case, according to his principle, he would have given the correct answer. Only his reason for the answer would have been erroneous. For the only legitimate reason that Carnot could have for applying his principle universally would be that he had proved that all reversible engines had the same efficiency between the same temperatures, so that his principle, known to be true for one body, must be true for all.

But this proof was vitisted by his erroneous assumption of the materiality of heat, then universally believed in, and was only put right long after, by Clausius and Thomson, on the basis of the equivalence of heat and work, fully established experimentally by Joule. Carnot founded his proof on a perfectly unexceptionable axiom (on his view of the nature of

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heat). Work could be obtained without any thermal agency if all reversible engines had not the same efficiency between the same temperatures. The substituted axioms of Clausius and Thomson are by no means so satisfying, considered as axioms. They express truths, they involve Carnot's principle, they involve the principle from which Carnot's is derived, but they are not axioms, unless a law of nature, only to be learnt by experience, is an axiom.

Clausius said that heat will not pass from cold to hot by itself, or without compensation. True enough, by definition of cold and hot, if the cold and hot bodies be in contact. Otherwise not self-evidently true, though a law of Nature. Thomson said we cannot get work out of a body by cooling it below the lowest temperature of surrounding objects. This I also admit to be true, knowing that it involves Carnot's principle, and believing that, but it is not self-evidently true. A third axiom that can be used is that we cannot convert heat into work without lowering the temperature of heat. This, I believe to be the best of all, being the simplest expression of the truth of Carnot's principle that work is got by lowering the temperature of heat.

Of course Carnot was wrong in his quantitative estimate of the efficiency of reversible engines, but his principle remains unaltered. When, with the principle of thermal resistance, we combine that of the equivalence of work and heat, and use Carnot's criterion of the perfection of an engine, that it must be reversible, we arrive at an absolute measure of temperature independent of any particular substance, and using it, give quantitative expression to the principle of thermal resistance, viz. :—

$$dW/dt = H/t,$$

where t is temperature according to the scale of equal dilatations of an imaginary perfect gas under constant pressure, whose energy, at constant temperature, is independent of its volume. It now becomes a form of the Second Law of Thermodynamics.

There is a reason for everything, and therefore (if that be an axiom) for the axioms of thermodynamics, better called laws. The reason of conservation of energy the student of dynamics can understand, if he can grant that the laws of matter in motion observed in masses are true for the smallest parts of bodies. The reason of thermal resistance is also, by the aid of the kinetic theory of gases, becoming evident, and will no doubt some day be established for all bodies. It arises from the irregular nature of the motions we call heat. We cannot control single molecules. Could we do so, down would go the law of thermal resistance and heat could be converted straight into work, molecular irregular motions to an equivalent amount of motion of a mass, the irregularity disappearing, without at the same time having to lower the temperature of another quantity of heat, as at present required. But what we cannot do with inanimate matter may be going on always to a certain extent in living matter; not because living matter is exempt from any law of Nature, but that we do not yet know all its laws. The perpetual running down of the available energy of the universe is a matter that must be cleared up. It is incredible that it can always have been going on, and dismal in its final result if uninterrupted. It is therefore the duty of every thermo-dynamitist to look out for a way of escape.

(To be continued.)

A NEW DYNAMO.

A contemporary, the Italian journal *Il Giorno*, illustrates a new dynamo recently constructed at the Tecnomasio in Milan, the design of which will be understood by reference to our annexed engravings. The bedplate of this machine is a heavy circular ring of cast iron, having at diametrically opposite points vertical extensions to which the field-magnets are attached. The latter are in line with each other, and it is claimed for this arrangement that the magnetic field is thereby made very symmetrical and intense. A similar disposition is found in the Hochhausen, the Van Depoele, the Türgensen, and the Thury dynamos, but in all these the masses of iron which serve as yokes are too near the poles, and disturb the field to a considerable extent. To judge from the illustration the new dynamo seems, however, to require a great deal of wire on the field-magnets, and it certainly requires more floor space than most of our compact English machines. The latter objection has been overcome in the vertical arrangement, which we also illustrate. The armature in this case is driven by a pair of friction cones and two belts running in opposite sense. In

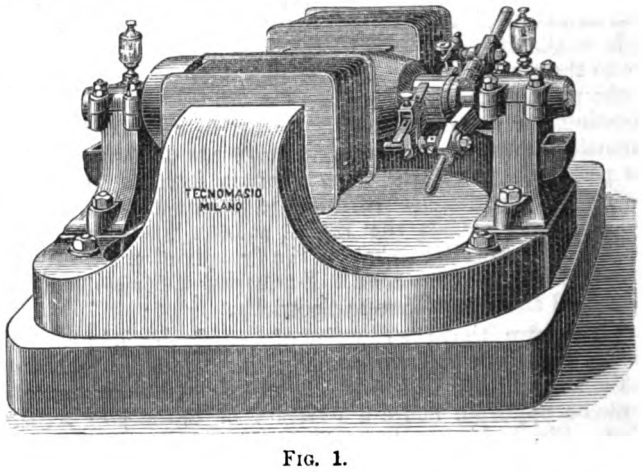

FIG. 1.

this way all side thrust on the bearing is balanced, and a device which permits the armature with its cone to be slightly raised or lowered serves to stop and start the armature. The chief reason for arranging the armature vertically is to overcome the difficulty of vibration in the spindle of horizontal armatures when the bearings are a great distance apart. According to the makers of this machine, a

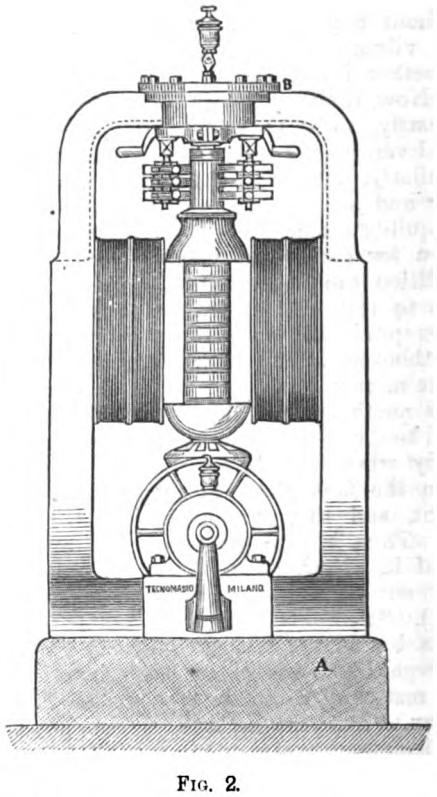

FIG. 2.

drum armature should be as long as possible, so as to give a maximum of electromotive force with a minimum of wire, and to make a very long armature mechanically possible they were obliged to resort to the vertical arrangement.

The soundness of this reasoning is, however, open to doubt. At the present time the tendency seems rather to be in the direction of short armatures of comparatively large diameter, as a cursory glance over the machines at the Inventions

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Exhibition will show. However, we cannot as yet say that a state of finality has been reached in the construction of

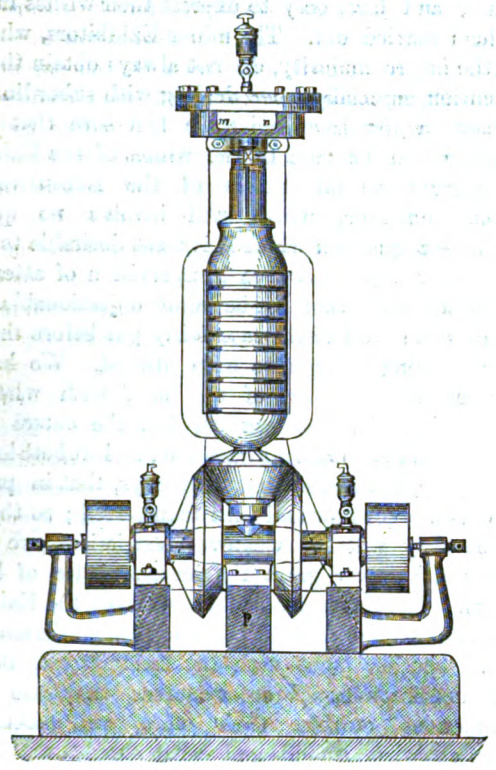

FIG. 3.

dynamos, and as the arrangements adopted by the "Tecnomasio" have at least the merit of novelty they deserve some attention.

LITERATURE.

Gas Engines By WILLIAM MACGREGOR. [London: Symons and Co. 1885.]

To write a first book on a subject which comprises the results of the work of a good many is not an easy task. To compile a book from the fragmentary writings of others is a much less difficult task, but it is still a troublesome work, and one which is likely in the end to be characterised as "paste and scissors." We will not describe Mr. MacGregor's book as worthy of this brief description, and we will give him credit for what he has done, and the difficulties he has had to encounter in this comparatively untrodden field of mechanical literature; but we must admit that we are disappointed. The author shows very considerable intimacy with the subject upon which he has written. He possesses a good deal of knowledge on the design, construction, and "nasty temper" of gas engines. But there is a world of gas engine lore that those behind the scenes possess which has not entered into the possession of the director of Mr. MacGregor's pen, or, at any rate, has not been published in his book. He has probably found that gas-engine builders are reticent, and object to tell him all that they have learned at enormous cost; he has been obliged to depend largely upon patent specifications, which, as every one knows, seldom contain the precise forms of detail which experience has, subsequent to the drawing of the patent drawings, found essential to success; and he frequently finds it necessary to say something of the same order as that at p. 97, where he remarks that "all of Atkinson's motors present novelties of ignition, regulation, and distribution that I regret it is beyond the scope of this work to consider." We might ask why, and with respect to the paragraph quoted, the reply would perhaps be that as some of Mr. Atkinson's novelties are not now used by him, it is not necessary to describe them. That the author has not been able to obtain satisfactorily complete drawings is a fault in the book with which we must not charge him, though we may object to the omission of the names of the inventors of the engines on the plates, while the words "MacGregor Gas Engine" are printed very large on each of them. The author's preface is not consistent with the book. When he wrote the preface the thermodynamics of the gas engine seemed to be a literary red rag, for speaking of these and of the cycles of Carnot, he says that "all reference to the cycles of Carnot and to the engine considered as a theoretical heat engine have been very carefully avoided. For in practice the gas engine has no affinity whatever to these cycles, except such as a straining of the truth to so great an extent as to exclude the effect of the most important practical factors as the cooling effect of cylinder walls might obtain. This is very clearly proved by a careful and unbiassed study of the practical cycles of the machine as given by the indicator diagram, and as involved in the consideration of the superior efficiency of high piston velocities. The superior economy of compression engines, and the relatively closely succeeding standard of the free piston engines, are facts that have not yet been satisfactorily correlated by any merely theoretical thermodynamic consideration." This is a curious mixture of truth and fiction, for whatever the effects of compression and high velocity of piston, the applicability of thermodynamics to any question of the efficiency of the engine as a heat engine remains the same, and it must be pointed out that that is not a "theoretic thermodynamic consideration" of the subject which does not take fully into account the whole of the practical conditions and facts involved. It is true that Carnot's cycle is not approximated to in the cycle in which a gas engine works, but the author is very far from escaping the application of thermo-dynamics to a consideration of the engine as a heat engine in the very copious extracts he gives from Mr. Dugald Clerk's paper on the theory of the gas engine read before the Institution of Civil Engineers in 1882.

A few words more and we have done with complaints. In those parts of the book which are of the author's composition a little more care might have been bestowed on the mode of expression. To the uninitiated, for instance, it would be difficult to understand the following, noted amongst other points which mark the Otto engine as distinct from its predecessors:—"By better employment of the heat generated in consequence of the cooling of the cylinder;" and again "the smaller powers use on an average 1 cubic metre per horse-power the hour, whilst for the larger constructions the consumption of gas is modified to about $\frac{3}{4}$ cubic metre," meaning that by the larger engines the consumption is reduced to $\frac{3}{4}$ cubic metre. What the following concerning Lenoir engines means is also enigmatic:—"Besides the advantage of a better and more economical expenditure of the gas by compression of the mixture before combustion, a gradual tension of the chief organ of the engine also assists this, and as well contributes to the object of a completely non-recoiling action." The reader of Mr. MacGregor's book is, it would appear, supposed to be perfectly cosmopolitan as to measures of all kinds, for we have in different parts, according as he is making up from one source or another, gas in cubic feet, cubic metres in another, and in litres in another; heat in British units and in centigrade units; work in ft. lbs. and kilogrammetres; length in feet, elsewhere in metres; cost in shillings and elsewhere in dollars. Temperature is, however, uniformly in centigrade units.

Now, of the book we may say that it is one which was very much wanted. For the greater part it is a compilation of more or less copious extracts from papers and reports, German, French, American, and English. The author has fairly taken the substance of these, although he might with advantage have given the diagram of the Crossley engine which accompanies Prof. Thurston's report published in *Van Nostrand's Engineering Magazine*, and from which he quotes extensively.

The book is valuable for its historic notice of the subject, and gives a good deal of information not generally known, showing how several inventors approached very near to success. That there is not much of original work in the book need not detract from its value, and although it is easy to see that much remains to be written on the gas engine, we have no hesitation in saying that Mr. MacGregor's work is one that should be in the possession of everyone interested in its subject.

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THE ELECTRICIAN.

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All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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EXHIBITORS AT THE INVENTORIES.

It will be seen from our correspondence columns that the Exhibitors at the South Kensington Exhibition feel that they suffer from grievances sufficiently strong to induce collective action. Since the opening of the Exhibition, complaints, verbal and otherwise, have reached us from the Exhibitors. We are rather slow in accepting as real all the little troubles that arise, but when we hear so continuously, and from so many sources, of mismanagement we cannot but think there is a reason for such complaint. Exhibitors are apt to forget the difficulties of organisation that beset the Executive. They imagine that their own particular grievance is the only one of magnitude, and often too hastily infer that the Executive is indifferent to their claims. Then the Executive is very much in the hands of *employés*, who may or may not carry out instructions with tact and discretion. It would be difficult to obtain so large a staff as is employed at the Inventories without finding by experience that some of its members are worse than inefficient. On the other hand, the Executive may look upon the ordinary exhibitor more like the pawn upon a chess board than as having any proper standing in the concern. Certain Exhibitors can always command attention to their requirements, and have only to express their wishes in order to have them carried out. The minor Exhibitors, who however form the larger majority, do not always obtain the same careful attention, especially when dealing with subordinates.

In the case of the Inventories, we feel sure that immediate attention will be paid to the wishes of the Exhibitors if fairly brought to the notice of the Executive. Let us take one example, which will involve no question of personality—a question which it is most desirable to avoid. The trouble over the renewal and supervision of attendants' tickets is on all sides said to be most objectionable. The Executive cannot have had the case fairly put before them, or the rules would long since have been altered. We have no knowledge of the members of the staff with whom the assistants are brought into contact, but the curses at the method and manner of treatment have been and are both loud and deep. It may be, as our correspondent says, that in previous years the tickets were now and then transferred; so they are now, and so they will be, whatever restrictions are placed upon them, and however great the inconvenience of holders getting them. The Executive could well meet the Exhibitors in this, and thus a large amount of unnecessary friction would be avoided. Another point with the Exhibitors is that the "walking superintendents," or whatever they are called, assume functions outside their office, and dictate to the Exhibitors what should and what should not appear upon the stalls. This has, we believe, been especially noticeable in the Electrical Section—so much so, in fact, that an almost unanimous agreement has been come to that the Exhibitors will withdraw their exhibits entirely. Collective action in this way would be a disaster, and in the interests of Exhibitors, the public, and the Executive, we may mention that when direct appeal has been made to the highest authorties it has resulted in the retention of the portions of exhibits objected to.

The Exhibition cannot exist without Exhibitors, and it is in the interest of every one desiring the success of the South Kensington work to assist in getting rid of defects and getting the machine to work smoothly. Were we in a captious mood we could give some very startling information about South Kensington, but we are fain to think that many things will, if left quietly alone, in some way or other right themselves. The question of the rules and regulations applying to exhibitions is, however, of pressing importance, and we shall offer the proposed Association every facility for placing their views clearly and forcibly before the Executive. We have sufficient faith in the business capacity of the Executive to foretel that any reasonable demand put forward by the Exhibitors will be granted without delay. *Bis dat qui cito dat* is probably the motto of the Executive, and we should be greatly surprised if it were not followed to the letter. No doubt the facilities offered by exhibitions for pure business purposes are discounted by the Exhibitors, and although it may be put forward that philanthropy and education are the mainsprings at work, these have to give place to the more practical question—Will it or does it pay directly or indirectly? If, therefore, the Executive were not to keep a pretty firm course, its work in the end would resolve itself into the management of a big bazaar and pleasure gardens. However far the real may be from the ideal, it is certain that South Kensington is expected to be more than a big bazaar, and the Executive something different from the directors of a public company, with the sole object of earning a dividend upon the capital invested.

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SIXPENNY TELEGRAMS.—A NEW PHASE.

Following on the decision of the Government to give every facility for the discussion of Mr. Shaw-Lefevre's Bill we have now what appears to be a semi-official announcement that his successor at the Post Office will submit an amendment to the House embodying the principle of Free Addresses, and "will abide by the result." This is news of some gravity; for an amendment of that kind will certainly find much support, and if pushed on in earnest may possibly be carried. In the interests of the public, as well as of the Telegraph Service, the new Postmaster-General will do well to "abide" in the sense of having saved appearances, and allow his political followers to remain equally passive. By this time he must have in his possession sufficient data to prove that Free Addresses are incompatible with any substantial reduction of the Tariff, which is the only thing the House or the public cares about.

But supposing Lord John Manners presses his amendment with enthusiasm, and Mr. Shaw-Lefevre offers it only a half-hearted opposition, what, we should like to know, is his lordship's alternative scheme? To simply reduce the charge to sixpence is utterly out of the question. Even to reduce the charge to sixpence, and the text of the telegram to ten or twelve instead of twenty words, giving the addresses free, would imply that either the late Postmaster-General's estimates and calculations were all wrong, or else that the present holder of the office thinks he can induce the Treasury to incur the enormous additional expense involved in signalling ten or a dozen extra words upon each telegram without charging more for it than Mr. Lefevre proposed to charge. Twelve words for sixpence was the utmost the late Government were prepared to offer; and even at that rate the new Postmaster-General has discovered that the prospective outlay had been seriously underestimated or disregarded. He will therefore hardly have the temerity to increase the limit to twenty or two-and-twenty words for the same money.

If Free Addresses are to be maintained with a reduced charge, the only alternative, it seems to us, is to reduce the existing rate a little, and the maximum text a good deal. Ninepence for ten words, with the addresses thrown in, is an alternative Tariff that might possibly pay, and we see no other. As the Department sends twenty-seven words for a shilling at present, it could perhaps afford to send twenty words for ninepence, especially as a ninepenny tariff would not be so oppressively popular as to necessitate a further large outlay on plant and staff in two or three years' time. But this question of popularity is the very essence of both the rival schemes; and the House will have to determine which of the two will be most popular—a ninepenny tariff, with the addresses free, or a sixpenny tariff with the addresses charged for. On grounds which have been stated many times in these columns we prefer the latter, or indeed any reasonably liberal tariff which at the same time charges for the addresses as an essential part of the message as a whole. And on this account we hope that some friendly understanding has been arrived at between the late and the new chief of the Post Office, so that the one may carry his Bill while the other will save his conscience.

THE E.M.F. OF THE RETINA.—Many efforts have been made to ascertain the E.M.F. of the retina and nerve of the eye, and to learn whether this quantity undergoes any alteration under the action of light. Some recent experiments have demonstrated the fact that the action of light is such as to vary the amount of electromotive force to the extent of about 3 to 7 per cent. of the total force. A strong flash of light enduring for the fractional part of a second produces, therefore, a marked effect.

CORRESPONDENCE.

SECONDARY BATTERIES: AN ELECTRO-CHEMICAL QUESTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am glad to perceive from your columns that M. Faure is continuing his work in connection with secondary batteries.

In regard to the question which has been raised as to the theory of the lead secondary couple, it is very necessary in the first place to exercise some care to avoid misapprehension, and, in the second place, to speak with some degree of diffidence, since it is sufficiently evident that there is much to be learned in this direction. If the "generally-accepted explanation" which is expressed by the equation,

$$Pb + PbO_2 + 2H_2SO_4 = 2PbSO_4 + 2H_2O,$$

be intended merely to embody the fact that in the working of the battery *some* peroxide is converted into sulphate, simultaneously with the conversion into the same salt of an equivalent of metallic lead, the theory in question cannot be controverted. Further than this, I think it may be admitted that, starting with an equivalent of spongy lead as the active material of the positive element, and an equivalent of lead peroxide as the active material of the negative element, it is *possible*, in presence of sulphuric acid in slight excess, to convert the whole of the active material into sulphate of lead by simply circuiting the couple. To obtain this result, which in my view is due to the fact that any compound which may be formed by residual lead peroxide is more or less rapidly decomposed by sulphuric acid (which would ultimately obtain sufficient access to it), a lengthy period of time would be necessary; for the initial potential difference of about two volts, remaining nearly constant until the peroxide had undergone a certain modification, would afterwards, with constantly diminishing rapidity, fall to zero.

But what I would venture to deny, on the basis of my own experience, is that this explanation is applicable to the conditions of practice. It fails to take into account essential details or steps in the chemical reaction which are revealed by variations in the potential-difference exhibited by the elements of the couple. In practice we consider a secondary cell to be quite discharged when the potential-difference falls to 1·8. In practice, again, I have found it expedient, with a view to diminishing the ratio of weight to useful work, to allow two equivalents of lead peroxide in the negative to each equivalent of oxidisable metal in the positive element. In practice (instead of the spent negatives being coated with a layer of white sulphate), the purple-brown colour—with something like a plum bloom and a peculiar softness of surface—which we love to see in the freshly-charged negative has merely changed to a light reddish-brown, or to a "cut chocolate" colour mottled with dark brown, and this tint extends throughout the substance of the element. In practice, any portion of the spent negative—whether from the surface or from the interior—evolves chlorine gas when treated with hydrochloric acid, *i.e.*, contains peroxide of lead, either free or combined.

Another suggestive fact is, that in the case of an insufficiently charged peroxide plate—where much peroxide has been formed, but in which some portion of oxide remains unconverted—we invariably fail to obtain, with an efficient spongy-lead positive, a potential-difference as high as two volts.

Now the questions—of equal interest in theory and in practice—which present themselves for solution are these:—

1. What proportion of the peroxide of lead present in an efficient negative element, mainly or wholly composed of this compound, is available for useful discharge, *i.e.*, for the production of a current under the potential-difference of about two volts, or not less than 1·8 volt?

2. To what cause is to be ascribed the comparative inefficiency of the residual peroxide, which, though abundantly present, either in a free or in a combined condition, gives with an efficient lead positive a potential-difference below 1·8 volt, and possibly much below 1 volt?

It may be some time before these questions can receive a

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satisfactory elucidation. I do not claim to be in a position to afford such an elucidation. I do not consider that my hypothesis, at the best, is more than an approximation to the truth. According to my suggestion, the reaction expressed by the equation given above—a reaction which I admit as *possible*, though not as *practical*—should, from an electrical point of view, be divided into at least two stages, indicated by the variation of potential. In this reaction, equivalents of lead and of peroxide of lead, with two equivalents of sulphuric acid, become converted into two equivalents of sulphate of lead and two equivalents of water. Doubling, for the sake of convenience, the number of equivalents involved, my suggestion is that the two steps or stages—neglecting complications due to the more or less perfect access of sulphuric acid to the interior of the negative element—would be as follow:—

(*a*). Giving a potential difference of about two volts.

$$2Pb + 2PbO_2 + 4H_2SO_4 = PbSO_4 + Pb_2O_3 + Pb + 3H_2SO_4 + H_2O.$$

During a period in which this stage overlaps the next stage, the potential falls more or less rapidly to about 1·8 volt.

(*b*). Giving an initial potential difference of about 1·8 volt, falling gradually to zero.

$$Pb + Pb_2O_3 + 3H_2SO_4 = 3PbSO_4 + 3H_2O.$$

When the useful discharge, due to the former reaction, is alone considered, equation (*a*), by subtraction from both sides of the residual quantities, involved in equation (*b*), of course becomes identical with the second equation given in my former communication.

I may mention that I have recently constructed two cells with spongy-lead positives; in one of which (A) a coil of platinum wire, constituting the negative, is in contact with lead peroxide; whilst in the other (B) a similar coil was surrounded with sesquioxide of lead (Pb_2O_3). In both cases the electrolyte is dilute sulphuric acid, in quantity more than sufficient to convert the lead compound into sulphate. In cell B the bright red colour of the sesquioxide has been almost completely converted into brown by the effect of the acid. I have just measured the potential differences of these two cells, which I find to be on open circuit as follow:—

A gives 1·99 volt.
B gives 1·79 volt.

When the reaction between the sesquioxide and the acid had only partially occurred, cell B gave 1·26 volt.

Professor Tribe somewhat underrates, I think, the stability of the sesquioxide of lead. If my memory serves me rightly, M. Levol, who in 1841 made a very careful investigation into the nature of the red lead compounds, characterises the sesquioxide as "a compound of remarkable stability"—an expression which I reproduced in my former letter. No doubt it is completely decomposed even by very diluted sulphuric and nitric acid; but the reaction is by no means as energetic as might be supposed. Those who have had occesion to prepare the peroxide of lead from minium, and who have experienced the difficulty of removing the last portions of monoxide by washing with nitric acid, may confirm this observation. In this operation the minium must be very finely levigated, and be digested in the first place with *boiling* dilute nitric acid. Even after this, much washing with nitric acid is requisite, in order to obtain the peroxide in a state of purity. In regard to the action of diluted sulphuric acid upon the sesquioxide, I recently added 520 grains of this compound to a mixture of one fluid drachm of sulphuric acid (sp. g. 1·84) with 10 fluid ounces of water. Although the weight of sesquioxide was sufficient to neutralise the acid, and did ultimately neutralise it, the mixture, in spite of energetic stirring, remained strongly acid for several hours. In this case the sesquioxide was in a condition of very fine subdivision. Had it been in the form of dense fragments the neutralisation of the acid would, I believe, have been practically an impossibility.

Mr. Swinburne, I observe, is sceptical as to the existence of such a compound as the sesquioxide of lead. He may obtain it, however, by treating any sample of "genuine" red lead with a solution either of potassic hydrate or of the normal acetate of lead until no more oxide of lead is dissolved. In the hydrated form the same compound may be precipitated by adding a solution of oxide of lead in potassic hydrate to a solution of potassic plumbate. Having obtained the compound Mr. Swinburne might be interested in testing its stability by subjecting it, in the first place, to the action of solutions of oxalic and of sulphurous acid.—Yours, &c.,

DESMOND G. FITZGERALD.

EXHIBITORS AT THE INVENTORIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On behalf of many exhibitors in the International Inventions Exhibition, and on my own account, I venture to submit to you, for publication in your well known paper, the following remarks as to the position and treatment of the exhibitors and their assistants (not attendants).

Premising that the success of the Exhibition is mainly due to the exhibitors, not only for the great teaching value and generally interesting nature of their exhibits, but also for the wide reaching influence they possess, in inducing their friends and business people to take an interest in, and to visit the Exhibition, I ask, what equivalent or counter advantage is given to them for the enormous money and brain outlay they have contributed, and for the continuing expense of attending their exhibits? My own experience is that absolutely nothing is given in return. It is an exploded notion that business results from exhibitions, or at least sufficient to pay the expense, and I venture to say that this is the opinion of most of the exhibitors after the two months' trial at the present Exhibition. Not only is there no equivalent, but the exhibitors are utterly ignored, only and excepting so far as they lend themselves and their exhibits to the money-making of the Exhibition. The bandsmen, waiters, and others have their recognised position, and are provided for, the official staff have their offices and club rooms; but the exhibitors, who make the Exhibition, are treated with an extent of coercion and repression which is unprecedented in any other Exhibition, and which has culminated in deep and serious murmurings and a feeling of discontent which will take a great deal to allay. The contrast between the treatment of exhibitors in this Exhibition and similar foreign exhibitions is most marked, and to those who have exhibited in both it is most humiliating.

The following are briefly the grievances of the exhibitors and their assistants:—

There is no writing or reading room for their use; there is no suitable lavatory provision; the weekly renewal of passes is most unnecessary and objectionable; the restrictions as to the limit of time and use of the passes should be abolished; complimentary tickets should be given to the exhibitors both for *fête* nights and other occasions; the subway toll should not be charged to exhibitors and their assistants. There are other and individual complaints which should receive consideration.

As to the renewal of the passes, my own recent experience will be interesting:—Owing to the absence of one of my assistants, I considered it better, to satisfy the officials, to use his ticket myself, which I did, attending and having it clipped for five days in succession. I presented the ticket for renewal, and was told by an officious gentleman in the office that because I had written my name across the ticket in pencil (there being no convenience to write it in ink, and no rule to that effect) instead of in ink, he would not renew my ticket! a culmination of red-tapeism than which anything more absurd or ludicrous it is impossible to imagine. I appealed at once to the secretary, and my appeal was at once attended to. Unfortunately the head man in the "*Attendants' Passes Office*" (I had been refused by his subordinate) was not in his office, so that I could not get the pass renewed that day (Monday), and in the meantime my exhibit is accumulating in dust. I mention this to show to what the officiousness of these subordinates is tending, and how necessary it is that action be taken at once.

An "Exhibitors' Association" has been formed, and a great many of the exhibitors and their assistants have already approved, and no doubt all the others who have not yet been

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solicited to do so will join. The objects of the association, as far as at present contemplated, are :—

1. To secure united action amongst the exhibitors and their assistants, to remedy grievances, and secure advantages.

2. To make exhibitors and their assistants known to each other for recommendation and mutual benefit.

The association is not inimical in any way whatever to the Executive Council, and is regarded with the greatest respect by each and all the members of that Council. We propose in due course to submit our grievances to the Executive, with the certain and assured feeling that our reasonable complaints have only to be known to be remedied. It is possible that an exhibitors' association may be of great assistance to the Council in future exhibitions, and help to ensure their success. On that account, I venture to hope it may receive the good wishes and support of the Council.

I have heard that the objection to giving assistants a pass for the whole of the Exhibition is that during the last Exhibition the passes were used by other than assistants. Suppose they were, the Exhibition was nevertheless a financial success, and surely the exhibitors and their assistants are entitled to some little grace. That the passes were used by others in a past Exhibition is not a good reason for treating the present exhibitors and their assistants with the suspicion and overbearing that is now the case.

As the representative journal of perhaps the greatest exh bit in the Exhibition, the "electrical and electric light," will you be good enough to give the association your valuable support, the use of your offices for meetings, and in other ways as you may think best ?—Yours, &c. HENRY B. JOEL.

Tower-chambers, Moorgate-street, London, E.C.,
14th July, 1885.

[We are quite willing to give the Association all the facilities it requires to place the views of the Exhibitors before the Executive.—ED. *E.*]

A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the "Exhibition Record" of 10th inst., p. 17, second column, lines 6, 7, 8, you say: "The two latter machines are running a high-speed Armington and Sims engine."

As the above statement is a little puzzling, seeing that the engine is running the two machines instead of the two machines running the engine, we should be glad if you would kindly correct that part of your notice, and oblige—Yours, &c.,

GREENWOOD AND BATLEY,
Sole makers of the Armington-Sims engine.

Albion Works, Leeds, July 14, 1885.

[The word "running" should have been replaced by the words "run by." The error is so obvious that it scarcely requires mentioning.—ED. *E.*]

ON A METHOD OF LOCALISING A PARTIAL EARTH IN A CABLE WHEN A RETURN WIRE IS NOT OBTAINABLE.

BY J. ANDERSON AND A. E. KENNELLY.

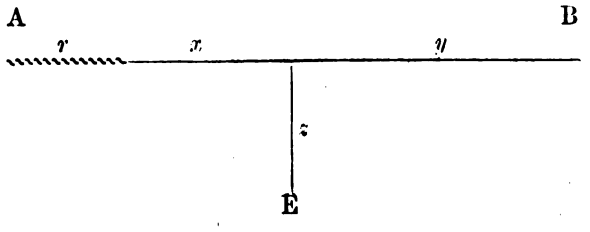
The method of fault-localisation herein described is based on no new principle, merely applying facts that have been known for many years, but which deserve more consideration at the hands of those who, like ourselves, have localisations to effect, and will, we hope, be interesting to electricians generally. In comparing theoretically methods of localisation and in estimating their relative value we have to ascertain the respective accuracies of which they are susceptible, and to what extent this accuracy is reduced by the probable behaviour of the fault during the tests.

The first consideration, that of the accuracy of measurement attainable, we may briefly name the sensitiveness of the method. This sensitiveness depends upon two things—one is the subdivision of units to which the required measurements can be carried, and is a purely physical factor; the other is the relation of the measured quantities to each other, in the formula giving the fault's distance, and is a purely algebraic matter. A good localisation method should possess sensitiveness in both these aspects—that is, it should be capable of considerable accuracy in the required measurements, and the numbers standing for those measurements should be so connected by the formula yielding the localisation that an error of observation in them may least vitiate the result.

The second consideration, above mentioned, the disturbance due to variation in the fault, is principally a physical matter depending upon the fault's position in the circuit, arrangements of the test, and its tendency to vary in electromotive force in consequence of that position. As it is obviously useless to acquire sensitiveness in localisation-methods, if that sensitiveness be annulled by the variations introduced by changes in the fault, it is necessary that a good method should have this source of error reduced to a minimum. This is usually sought by making the time which elapses between the measurements as short as possible, so that the fault may not have sensibly altered in condition between the two, and when the measurements can be taken simultaneously from each end of the cable this is best secured.

For the purposes of this paper there are only two methods which we need consider, and these are the Varley loop test and the Blavier test, with its modifications. We shall examine them in detail, and endeavour to show that the Varley loop test satisfies the requirements for a good method just stated in a high degree, and that the ordinary Blavier test does not possess those qualifications, but that modifications may be made of the Blavier method by which much of the value of the Varley test may be gained after due allowance is made for the loss of general efficiency through the absence of a loop or return wire.

In the Varley loop test the sensitiveness of measurement is high, for it has all the accuracy of which, under the particular circumstances of the test, the Wheatstone bridge, the most sensitive of measuring instruments, is capable. Its algebraic sensitiveness is also large, for any error of observation in the measurement of the resistance producing balance produces only half that error, in the result giving the fault's distance. Added to this, there is but little loss of sensitiveness through disturbance due to fault variation, for the loop test is practically a simultaneous measurement from each end of the line with a fault in the centre of it, so that variations of the fault affect each measurement equally and synchronously. We see, therefore, how fully the Varley loop test satisfies the conditions we have laid down for estimating the relative value of different methods, and the high rank it has always taken in practical value is thus accounted for. In fact it is only when the loop of cable is of great length and its normal insulation comparatively low that there is any uncertainty in the results given by it. We shall now examine the Blavier method with the aid of the accompanying figure.



A and B are two stations between which is a faulty cable of total normal conductor resistance l. x and y are the distances of the fault from each end of the cable, so that $x+y=l$. The resistance of the fault is z, and r is an adjustable resistance added to the end of x at station A.

In the ordinary Blavier test r is removed or is zero, and one or both stations measure the resistance of the line when the distant end is freed and earthed.

Let f be A's measurement when B frees.
„ f' „ B's „ „ A „
„ e „ A's „ „ B earths.
„ e' „ B's „ „ A „

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Then supposing both stations tested, we obtain four equations by which the fault's position may be found.

$$x = \quad e - \sqrt{\{(f-e)\ (l-e)\}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$x = l - e' + \sqrt{\{(f'-e')\ (l-e')\}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$x = \frac{f}{2} - \frac{f'}{2} + \frac{l}{2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$x = e \times \frac{l-e'}{e-e'} \left\{ 1 - \sqrt{\frac{e'\ (l-e)}{e\ (l-e')}} \right\} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

The first two equations are similar, and the same reasoning will apply to both.

Theoretically, in the tests to which these two equations relate the measurement of f is perfectly sensitive, and e not perfectly, but sufficiently sensitive for all practical purposes; also there is no considerable want of sensitiveness in the equation algebraically. There is, however, much liability to disturbance in the measurements, owing to fault variation, and this generally prevents the method from yielding reliable results.

When the same battery power is employed for measuring f and e the fault is necessarily at a higher potential in the circuit for f than it is for e. Consequently, as the resistance of a fault is some function of the current passing through it, there is a tendency for the fault to vary between the measurements. This variation also affects the measurements unequally, for in f any variation of resistance v in the fault produces a corresponding change of v in the measurement of f, but the same variation of the fault in observing e produces a change of

$$\frac{y\ (z+v)}{y+z+v} - \frac{y\ z}{y+z}$$

$$= \frac{vy^2}{(y+z)\ (y+z+v)} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$= v\left(\frac{y}{y+z}\right)^2$$

approximately in the measurement of e. This quantity is, of course, always less than v.

The only means of reducing this source of error is to employ a smaller electromotive force in observing f than that for observing e, and we can approximate to the proper ratio between them by a simple calculation. This plan is practically the best to adopt in Blavier tests, but even then the polarisation of the fault alters between the two measurements, for earthing the cable at B makes y a shunt to z, and this source of error cannot be brought under control. It is, therefore, seldom that this formula enables a localisation to be satisfactorily effected.

Turning now to equation 3 we obtain a more promising combination. In the first place f and f' are both limited in sensitiveness only by the range of the measuring instrument, and in the next place, algebraically, there is a gain in sensitiveness for any error in observing f when f' is correct, or in observing f' when f is correct produces only half that error in x, the fault's distance. The liability to error is in such variation as may take place in the fault between the two measurements. This is best reduced by placing the fault at the same potential in each measurement, and in taking the measurements as quickly as possible after each other. Practically it is best to add resistance to the lesser of x and y until it is found that f and f' are equal, also employing at each end the same battery power and the same ratio in the arms of the bridges. The readings are taken to cable-current zero, and as swiftly in succession as may be. When this is done we obtain theoretically a Varley balance in everything but synchronism and exactness. The formula for the Varley balance also applies, for if r in the figure be the resistance that has by successive trials to be added to x in order to make $f = f'$, then

$$x = \frac{l-r}{2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

When for any reason the "fall of potential" method cannot be employed this test often gives good results. By maintaining the same strength and direction of current through the fault during each measurement the tendency of the fault to vary is reduced to a minimum. It frequently happens, however, that the resistance of the fault is so variable that, notwithstanding all precautions, f and f' cannot be properly measured. It is to meet such cases in a more suitable way that we bring to notice a method not yet published so far as we are aware. This method is a modification of equation 4, which we will now examine.

In this equation we notice that, instead of the gain in algebraic sensitiveness we have mentioned in equation 3, there is a considerable want of sensitiveness; for in the condition best for measurement and for least disturbance from fault variation, namely, when e is nearly equal to e', or when, that is to say, the fault is near the centre of the line, an error in observing e or e' produces a considerable error in the result, for the difference $e - e'$ is then the denominator of an improper fraction. If e and e' be very unequal it is then difficult to arrange the testing batteries at each end so that the strength of current passing through the fault shall be the same in each measurement, and it is impossible to maintain precisely comparable measurements, even though this were done, as the polarisation of the fault will alter in each case, being shunted by different resistances. Probably owing to these reasons this formula is seldom employed. One advantage, however, this case possesses, and that is the steadiness of e and e', compared with f and f' when the fault is very variable, as shown by Equation 5; in fact, the variations of the fault are shunted down.

In the method we bring to notice it is proposed to unite the advantages of equations 3 and 4 by adding resistance in successive trials to the lesser of x and y, until $e = e'$. When this is done another modification of Varley balance is obtained, and if r be the resistance added to x in order to make $e = e'$

then, as before, $$x = \frac{l-r}{2}$$

It is true that in order to obtain measurements less disturbed by fault variation this test, which we may call the balance of e and e', loses a certain amount of the theoretical sensitiveness of measurement possessed by the balance of f and f'; still, in practice when the fault is very variable, there is generally a decided gain on the whole from the absence of disturbance in these measurements.

In obtaining the balance between f and f', supposing the condition of the fault to be constant, r is obtained by one measurement of f and f', for it will be approximately $f' - f$; but in balancing e and e', r has to be found by successive approximations, for if $e' - e = n$ when $r = 0$, and we make $r = n$, then e'' will become

$$e' + n \times \frac{z^2}{(x+z)\ (x+z+n)} \quad . \quad . \quad . \quad . \quad (7)$$

and e will become $e + n$. So that the difference between the new values of e and e' has become reduced from n to $n \times \frac{z^2}{(x+z)\ (x+z+n)}$, and where n is small relatively to x and z this is approximately from

$$n \text{ to } n\left(\frac{z}{x+z}\right)^2$$

If, now, $n\left(\frac{z}{x+z}\right)^2$ be added to r, r will be $n + n\left(\frac{z}{x+x}\right)^2$ and the difference between e and e' will be further reduced to

$$n\left(\frac{z}{x+z}\right)^4$$

approximately; and so increasing r each time by the difference between e' and e, we should, supposing the fault constant, arrive at a difference between e' and e equal to q. Suppose where

$$n\left(\frac{z}{x+z}\right)^{2s} = q,$$

q would be the limit of appreciation for the measuring instrument, and s would be the number of values given to r in suc-

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cession before balance was obtained. Suppose the original difference between e' and e to have been $50^{\omega} = n$, and $x = z$ also the limit of appreciation in measurement to be $0{\cdot}1^{\omega}$, then

S = between 5 and 6,

or balance would be found after r had been readjusted five times. Practically, however, instead of following this approximation process it would be preferable to ascertain roughly by some other method the value of r to be first tried, and then balance would soon be obtained except in so far as the variation of the fault would disturb the readings.

It is evident that the theoretical sensitiveness of this test is reached when (supposing the fault constant) a change made in r makes a change less than the limit of appreciation in the bridge at B. We can ascertain what degree of sensitiveness we obtain for any given cable and fault. This limit is reached when a change in r of an amount m produces the smallest appreciable difference in the reading at B.

Suppose that B can observe to μ units. When balance is nearly obtained, $x + r = y$ approximately.

Let $y + z = \phi$ and $\frac{yz}{y+z} = p$.

Then $$\left(y + m + \frac{yz}{y+z}\right) - \left\{y + \frac{z(y+m)}{y+z+m}\right\} = \mu$$

$$\therefore m + p - \frac{z(y+m)}{\phi + m} = \mu$$

$$\therefore m^2 + m(y - \mu + p) = \mu\phi$$

$$\therefore m = \frac{\sqrt{\{4\mu\phi + (y - \mu + p)^2\}} - (y - \mu + p)}{2}$$

or approximately $$m = \mu\left(\frac{y+z}{y+p}\right) \quad \ldots\ldots\ldots \quad (8)$$

Thus m is always greater than μ, and m diminishes as z increases relatively to y. That is to say, the greater the resistance of the fault is to the distance y, the less will be the sensitiveness of the measurement.

To take a case, suppose y to be 1000^{ω}, and z to be 5000^{ω}, and that A and B have bridges by which $0{\cdot}1^{\omega}$ can be appreciated, then

$$m = 0{\cdot}1\left(\frac{1000 + 5000}{1000 + 8333}\right)$$

$$= 0{\cdot}33^{\omega}.$$

Or, supposing the fault constant, and that A and B observe correctly, the fault could be localised to one-sixth of an ohm, since the added resistance r could be adjusted to one-third of an ohm. The method of balancing f against f' would in this case have theoretically localised the fault to one-twentieth of an ohm, but would have been much more subject to disturbance from fault variation.

The following are some readings that were obtained with an artificial fault made between two lengths of cable coiled in a tank. The fault was made purposely in such a manner as to give a somewhat high and variable resistance, x was 43^{ω}, y was 367^{ω}.

The resistance of the fault z by bridge from the end B with ten Leclanché's was found to be 400^{ω} at first, rising to 900^{ω}.

e' was then observed, while r was 0 e' was 440^{ω}

e was next taken with the same battery and direction of current

e was found to be 350^{ω}

r was then made 100^{ω}

e' was then 510^{ω} e considerably less

r was increased to 250^{ω}

e' was then 630^{ω} e still lower

r was next increased to 300^{ω}

e' was then 668^{ω} e still a little less

r was again increased to 350^{ω}

e' was then 709^{ω}; e more than e'

r then reduced to 325^{ω}

e' then 700^{ω}; e was a little more than e'

r was therefore reduced to 321^{ω}

e' was then found to be 695^{ω}; e was lower

r increased to 330^{ω}

e' then $694{\cdot}5^{\omega}$ e was then higher

r altered to 325^{ω}

e' was then found to be 693^{ω}
e ,, also ,, ,, 693 } Balance.

The correct resistance for balance would have been 324^{ω}.

The balance of f and f' was then tried with the same battery and direction of current (zinc to line), but nothing reliable could be obtained from the rapid variation of the fault. With copper to line, however, the fault was much steadier, and a good balance was obtained. Still, the balance of e against e' was obtained when it would have been impossible to get the readings of f and f', the above balance being 325^{ω}. The distance of fault $x = \frac{410 - 325}{2} = 42{\cdot}5^{\omega}$, the actual distance 43^{ω}—an error of half an ohm. In this case allowance must be made for the rapidity with which the readings could be made to follow each other, and the general increased chance of accuracy, through one observer and one set of instruments; but even after all deductions are made on these accounts the method shows itself to be a very useful one.

The *rationale* of the method in practice might be as follows:—A and B obtain an ordinary Blavier test to approximately localise the fault. This done they arrange to earth their ends alternately, adding to the lesser of x and y, suppose to x, the resistance r assumed to approach balance. B now observes e' while A earths, then communicates with A on the cable and gives him his measurement. This A inserts in his bridge and adjusts r until he obtains balance while B earths. A then earths and B again observes and so on until balance is obtained in each case with r. In both balancing f against f' and e against e', it is necessary that both observers read to false zero, and in the same general manner, otherwise their readings will not be comparable.

We have now described a method for localising variable faults which, although not so sensitive in point of measurement as the balance of f and f', or other tests, is, we think, more free from the troublesome disturbance of fault variation than any other on a single cable that we are acquainted with, and consequently one which we believe will be found useful. The theoretical limit of accuracy to which it is capable of being employed we have indicated, and an estimate has been furnished for the amount of depreciation in the results through fault variation by equation 5.

The method has already proved its value in one actual case, and that alone has amply returned the time given to its development. We trust that it may be found useful by others, and that it may at least occupy that place, whatever it may be, in the list of localising methods which experience shall prove it deserves.

Since writing the foregoing we have had an opportunity of applying the balance of e and e', which we may call the earth overlap test, to two cases in actual practice, with the following results:—

The first case was a cable over 600 nauts. in length, with an extremely variable fault 10 nauts. from one end; this fault had from $1{,}500^{\omega}$ to over $3{,}000^{\omega}$ resistance, and changed so rapidly that no reliable results could be obtained with any of the ordinary methods. The mean of a series of nine-earth overlap tests, however, localised the fault to within two and a half nauts. of its true position, while the widest variation between any two of these tests was about six nauts., which we consider satisfactory when the very variable nature of the fault is taken into account. In the second case the length of line was over 1,100 nauts. with a fault 150 nauts. from one end. This fault had about 550^{ω} resistance, and was

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much steadier than in the first case. As there was a second line the result obtained by the earth overlap test, namely, 1,418$^{\omega}$, could be checked by a Varley loop, which gave 1,426$^{\omega}$, a difference of only three-quarters of a naut.

ON THE CALCULATION OF MAINS FOR THE DISTRIBUTION OF ELECTRICITY.*

BY W. H. SNELL, ASSOCIATE.

(Concluded from page 161.)

Now, as long as we have only or mainly to deal with lamps belonging to Group I. ("Regular" division), we can obtain nearly the true values of A and B without much trouble. Afterwards we may, if we please, continue to work out these values by means of formulæ similar to those already discussed in collating the groups; or we may content ourselves with assigning the limiting values of ϕ_x.

These values are, for the maximum,

$$\phi_x = S_x + \phi_y + \phi_z \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (37)$$

and for the minimum,

$$\phi_x = \left(V_x + V_y' + V_z'\right)\sqrt{\frac{T}{t}} \quad . \quad . \quad . \quad . \quad (38)$$

where V is equal to the sum of the values of M for the different groups of the given section; M, as before, being the number of lamps corresponding to the mean lighting current for the several groups. Indicating the different terms of M similarly to those of N previously given, we shall have

$$V = (M_1 + M_1' + M_1'' + M_2 + M_3 + M_3'' + M_4 + M_5) \quad . \quad . \quad (39)$$

The values of V corresponding to the *final* lighting current for the section are distinguished by a dash. Thus

$$V_x' = V_x + V_y' + V_z' \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (40)$$

When working in this way it will usually be desirable to retain the two limiting values of ϕ all through until the calculations are complete. We shall then be better able to decide how many and what different sizes of conductors should be actually laid down. In finally choosing a value between the limits, it must be remembered that we have uniformly assumed that the lamps are placed at the extremity of each section, and that we have thus introduced an error in excess. Other errors contained in the formulæ are (probably) mainly due to the exclusion of the "Irregular" lamps in certain places, and are thus errors of deficiency.

It will be obvious that any value of ϕ may be directly determined by treating the given section as though it was terminal, distributing all lamps supplied through it into their several groups, finding values for N and collating them as before. This process would usually involve much extra trouble, especially if there are many installations belonging to Group II. But for determining the dimensions of "feeders," and similar sections of any considerable length, it would probably be worth while to undertake the work.

Equation of Economy.

Returning now to the "equation of economy," it may conveniently be put into the form—

$$W = C_\theta \sqrt{\rho b} \quad . \quad . \quad . \quad . \quad . \quad . \quad (41)$$

Where C_θ is the final thermal current for the given section, W is the weight of the required conductor in pounds per unit length, ρ is the resistance of a conductor of unit length weighing one pound, and b is a term constant for any given installation within certain limits and depending only upon the financial data.

If we take 100 yards as our unit of length, and assume a working temperature of 25° C. and a conductivity of 95 per cent., we shall find that

$$\rho = 3^{\omega}.$$

(Strictly, $\rho = 3{\cdot}08^{\omega}$; but as neither temperature nor conductivity are known absolutely, we may as well take the whole number.)

*Paper read before the Society of Telegraph-Engineers and Electricians.

It may perhaps be thought that in (41) we should rather use the value $C_\theta \sqrt{\frac{T}{t}}$ as representing more nearly the actual current during the hours of working. We may certainly do this without error, for it will lead to the same value for W. This will be seen on examining the term b.

We have

$$b = \frac{{\cdot}00134\, z}{\beta(p + a)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (42)$$

Here z represents the cost of 1 E.H.P. per annum *developed continuously;* but if we increase C_θ to $C_\theta \sqrt{\frac{T}{t}}$ we shall have to take z for an average of t hours per day, consequently $\sqrt{b}$ becomes $\sqrt{b\frac{t}{T}}$, and in (41) W remains unaltered.

In estimating z we shall of course remember that the engines run q hours only per annum, and therefore we must find the cost of Q hours running at the particular rate per hour found for q hours.

In the above expression for b, β is that fraction of the first cost of the cable which is to be charged annually for interest and maintenance, p is the cost of copper per pound, and a represents an expression for the cost of insulation and protection *per pound of copper in the cable*, so far as this is not a constant sum. a may be of a form which does not admit of the direct determination of W in terms of C_θ, in which case we shall have to prepare tables of the values of C_θ for different values of W, and the value of b will then vary in different parts of the system.

Having found W—the weight of the required conductor per unit length—it is worth while to note that for a cylinder of copper we may put

$$d = 2\sqrt{\frac{W}{l}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (43)$$

where d is the diameter in inches, l the length in inches, and W the weight in pounds. In this case, the length being 100 yards, this reduces to

$$d = \frac{1}{30}\sqrt{W}.$$

In (43) the true log. of the coefficient is 0·300935. The formula is useful for finding the *effective* diameter of stranded cables.

Limiting Distance of Lamps.

Professor Forbes has shown that in any installation the distance of any given lamp from the nearest point of constant potential must not exceed a certain limit. Put this equal to L yards, and let e be the maximum variation of potential permissible, let r be the resistance per unit length of the cable, and let this unit length be l yards, then we must have

$$e = C r \frac{L}{l}$$

$$\therefore L = \frac{l e}{C r} \quad . \quad . \quad . \quad . \quad . \quad . \quad (44)$$

Now in this expresion for L we shall have $l e$ constant throughout the system, so that if L is to be constant we shall only require the condition $C \propto r^{-1}$. But this condition is fulfilled only when C is either equal to the thermal current or bears some constant ratio to it, and only then (as will presently appear) while the value of b is constant in the different parts of the system. Professor Forbes, in his recent Cantor lectures, seemed to imply that it would be sufficient to adjust the extreme variation of potential to the *average* current. But it seems doubtful whether this would be permissible in practice, because when there are any large installations in occasional use the maximum current is likely to be so much larger than the average. It appears to me, therefore, that in (44) C should be taken nearly, if not quite, for the maximum number of lamps which will ever probably be in use at one time. I should propose to obtain this maximum number by taking the total number hung, and deducting from this (1) say, one-half of the "Irregular" lamps, (2) all lamps in Group I$_A$,

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(3) all lamps in Group I. which are extinguished before any of those in Group II. are lit. In this case the ratio $C\theta : C$ will not be constant throughout the system. Hence the values of L will also differ in different districts.

Let C_1 be the value of this maximum current in the first district, and indicating the particular values of the other terms in (44) by the same subscript, we have

$$r_1 = \frac{\rho}{W_1};$$

so that $L_1 = \frac{l e W_1}{C_1 \rho}$. Substituting for W_1 from (41),

we have $$L_1 = l e \frac{C\theta}{C_1} \sqrt{\frac{b}{\rho}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (45)$$

Now in this expression, whatever be the values of the units chosen, we shall have $(l \rho^{-\frac{1}{2}})$ constant, and (to give L_1 in yards) equal to 57. So that (45) becomes

$$L_1 = 57 \times \left(e b^{\frac{1}{2}} \frac{C\theta}{C_1} \right) \quad . \quad . \quad . \quad . \quad . \quad (46)$$

I may, perhaps, be permitted to mention, in conclusion, that I have elsewhere shown that the limits of L_1 are largely extended by the use of "multiple mains" when the relative dimensions of the external and intermediate mains are properly proportioned.

LARGE SECONDARY BATTERY PLANTS FOR COMMERCIAL DISTRIBUTION.*

We abstract the following from the American *Electrician*, to which Mr. E. P. Roberts, M.E., contributes the annexed description of a large secondary battery plant for general commercial distribution, at the same time quoting a description of "battery plant" previously given :—

"On each block—sometimes on every two blocks—is located a small portable house, in which are placed all the batteries furnishing light for said block. A partition divides it into two parts, one for the batteries and the other for the meters and switch-board. A plug switch is used in order that any combination may be readily effected. Cable connections permit coupling batteries together as desired. An extra battery is kept in each house for use in case extra light is required.

"The batteries are placed on string pieces 2in. by 4in. by 10ft.; each cell rests on four porcelain insulators, and the string pieces rest on Western Union insulators with pins set in cross pieces. Three sizes of batteries are used, 1, 2, and 3, with capacities of 20, 40, and 80-lamp hours respectively.

"Three charging circuits are used, two to private residences, where Nos. 1 and 2 batteries are used, requiring from 7 a.m. to 1 p.m. to charge them with a 10-ampere current, and one circuit to the business part of the city, where batteries are used. As these batteries are much larger, a longer time is required to charge them, and therefore they are charged from 7 a.m. until 3 p.m. by a 65-light dynamo. They are then connected by switch, as desired, for the night, in some cases three batteries being connected for quantity.

"At dark the charging circuit is looped in with the all-night outside arc circuit, and the charge thrown on about 20 meters, and by the connections for quantity controls about 50 batteries; thus they are left until daylight, when the arc circuit shuts down. By this means the batteries obtain considerable charge; they are then disconnected and charged separately during the day."

Directions for Erecting and Maintaining Storage Batteries.

A. Careful Insulation.

1st. Battery as a whole well insulated from the earth.

2nd. Each cell insulated from all others, excepting, of course, through the proper channel for the passage of current.

3rd. The positive and negative in each cell to be insulated from each other, except through the liquid. No connection by moisture on the upper edge of the containing box.

B. Regular Charge and Discharge.

1. Fill the battery every day.
2. Discharge the battery every day.
3. Never over charge.
4. Do not exhaust completely.

C. Do not expect batteries to take care of themselves.

1. Test electromotive force of each once a week with a voltmeter.
2. Test each cell with an acidometer once a month.
3. Each day see that each cell in each battery fills in the same time.
4. Keep plates covered with liquid.
5. Examine all connections frequently.

D. Keep extra cells complete and charged, with which to replace defective ones. Do not put uncharged plate or cell in battery in regular use.

E. Do not "box in" batteries. Give free circulation of air.

F. Keep all connections, switches, &c., as far as possible away from batteries.

G. Study the cause producing a new effect, and attend to details.

Remarks.

After considerable experience with storage batteries, my conclusion is that they have been both praised and belittled too much. That the service can be good is certain; but that for a closely settled district they are preferable to dynamos is not, according to my experience, correct.

Experience teaches the manufacturers many points in design and formation which greatly increase the reliability of secondary batteries. Experience in handling them teaches men many little matters which greatly assist in keeping the batteries in good condition.

My plan for our new station about to be erected will show, more forcibly than a lengthy disquisition, my ideas respecting secondary batteries in connection with stations for the distribution of electrical energy.

A building is to be erected near the business portion of the city, from which our arc lights will be supplied, and in which also will be placed dynamos for running the incandescent lights in the business district. Batteries will be used in portions distant from the station. These will be charged from 3 a.m. until 7 a.m. with a 15-ampere current. At the station will be several large batteries, which will be used for day lighting or in case of a breakdown.

AUTOMATIC BICHROMATE BATTERY.

This new arrangement of bichromate battery being of small dimensions, *i.e.*, 7½in. by 1¾in. by 8½in., and weight 6lb., may be said to be especially adapted for use in mines, &c., on account of its portability. One charge will, we are informed, light a 5 candle-power lamp for about two hours. The accompanying illustration will readily explain the special features of the battery. The electrodes are attached to an ebonite plate supported in position over the liquid by the upper edge of the containing case, within which is placed a more shallow case, constituting the liquid reservoir. The reservoir itself is free to move up and down without any possibility of disarrangement, and rests upon a small roller connected with a lever at the bottom of the case. By moving this latter the liquid reservoir is raised, and its contents "immerse" the electrodes. A ratchet arrangement prevents disconnection being made until the battery is out of use. By this arrangement, requiring the use of one hand only, an accurate regulation of the electrodes can be obtained; further, it is easy by raising or lowering the liquid reservoir from time to time, while the battery is in use, to displace the gas which gathers upon the surface of the electrodes, in consequence of their polarisation. The battery is easily recharged, the lid being opened; the ebonite plate referred to above as bearing the carbons and zincs can be lifted up, and the cells then be emptied and filled with bichromate solution. This battery, with surgical and other accessories, is manufactured by

* Read before the American Institute of Electrical Engineers, May 20, 1885.

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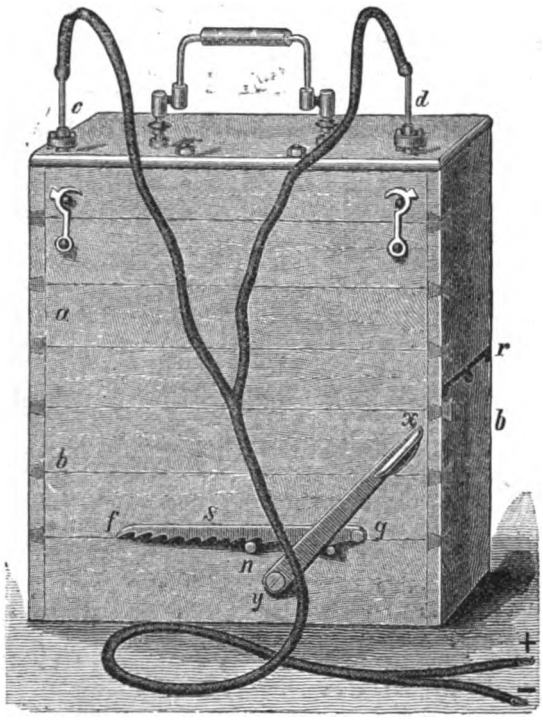
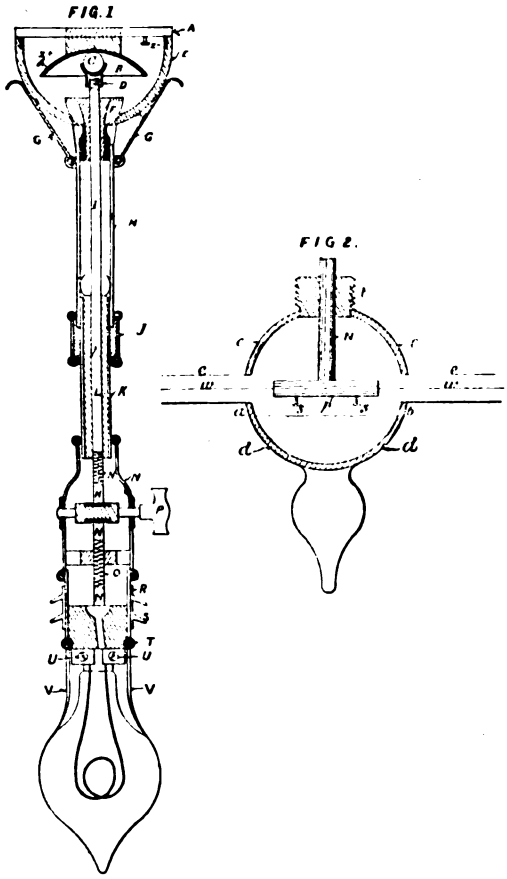
Messrs. Woodhouse and Rawson, 11, Queen Victoria-street, London, E.C.



The same firm also forward us a list of their primary batteries, which includes many of the late types of well-known elements.

GRUNDY AND READY'S TELESCOPIC PENDANT ELECTROLIER.

The electrolier is composed of two tubes, H and K, as in Fig. 1, sliding one within the other through a shifting box, J,



similar to a cork slide gas pendant. These tubes in connection with the ceiling plate A form one electrode, the other one being formed by the inverted cup B, which is insulated from A, the ball C and the rod I which slides in an inner tube L. The pendant swings and rotates in a sort of cup and ball joint at F, the contact between the outer tube and the cup E being assisted by the springs G G, and that between the inner rod I and the plate B by the spiral spring D under the cup and ball C. The switch P dispenses with the cost of wire labour, &c., in running a switch to a convenient place on the wall or other part of the room.

Any number of ceiling plates can be fixed in different rooms, and the wires being attached to them and not to the pendant itself it can be moved from room to room at will. If wanted for more than one light the attachment (Fig. 2) takes the place of the lamp holder, and any number of arms can be added or attached by any person in a few seconds. The stock size is capable of carrying six lamps at one ampere each, and yet is not too heavy looking for a single-light pendant. In this pendant there are no cords or pulleys to get out of order; the whole thing can be thoroughly relied upon, and a short circuit is impossible. It is fitted with a holder for plain lamps, but almost any centre contact fitting can be employed. The drawing is only intended to show the construction of the parts, but the desired ornamentation can be added at will.

LEGAL:

United Telephone Company (Limited) v. Bassano and another.

In the High Court of Justice (Chancery Division), before Mr. Justice North, this case came on for hearing this week. It was an action for an injunction and consequential relief in respect of the now well-known Edison patent for a telephonic transmitter, being part of the invention comprised in letters patent of July 30, 1877, granted to Mr. Thomas Alva Edison for "Improvements in instruments for controlling by sound the transmission of electric currents, and the reproduction of corresponding sounds at a distance." The patent, in respect of which three several disclaimers have been filed, is now the property of the plaintiffs, and has become a familiar subject of litigation in the courts. The present proceedings were restricted to the transmitting instrument as distinguished from the "receiver," and the alleged infringement consisted in the sale by Messrs. Bassano and Slater, the defendants, of telephones manufactured according to letters patent granted in 1883 to Messrs. Bassano Slater, and Hollins. The case was opened by the Attorney-General, who, with Mr. Aston, Q.C., Mr. Cozens Hardy, Q.C., Mr. Moulton, Q.C., and Mr. Micklem, appeared for the plaintiffs. Mr. Bigham, Q.C., Mr. Macrory, and Mr. Plumptre were for the defendants.

Sir Frederick Bramwell gave evidence for the plaintiffs. He had examined the various specifications and descriptions which were set up as anticipations of Edison's patent, and had come to the conclusion that it was a new thing at the date of Edison's patent to use anything that was caused to vibrate by sound valves, combined with a tension regulator in a closed circuit, so as to operate as a telephonic transmitter, except that there was a water telephone referred to in Morgan Brown's specification, and which formed the subject of Edison's sixth claim, now disclaimed. The water telephone could not present intimacy of surface-contact, which was of the essence of Edison's principle.

Cross-examined by Mr. BIGHAM, Q.C.: Edison's claims were originally 30 in number, but were now reduced to one. The meaning of that claim could only be ascertained by reading the general disclaiming words, and it was a combination claim, but he submitted that any question of opinion was for the Court. In Edison's patent transmitter the diaphragm was not within the resonant tube; it was at the end of it. The diaphragm of the defendants in the case against Harrison, Cox-Walker, and Co. was a sheet of platina foil acted on by the sound wave on the one side and itself acted on a large surface of pounded coke on the other side, and was by common consent itself the conductor of the current. That diaphragm (Hunnings) came in contact with the tension regulator, in effect performing the same functions as Edison's diaphragm. It intervened between the lips of the speaker and the regulator. In Edison's patent the diaphragm always comes between two parts of the same instrument. The board to which the instrument is attached at the back, supplemented by the enlargement at the termination of the resonant tube, is what corresponds in defendants' instruments to Edison's diaphragm, by receiving the sound waves and transmitting them to the tension regulator. The tension regulator in defendants' instrument is fastened to and is within the enlarged portion. The voice sets that portion into vibration, and those vibrations exert pressure on the tension regulator. The instrument will speak when used without the board at the back. The tension regulator unaccompanied by the diaphragm would be a commercial failure, because the sound waves act on the diaphragm, which in turn acts on the tension regulator; the combination is consequently essential. The addition of the board adds to the effect of the transmitter. Witness was not sure whether the tube was part of the diaphragm, or performed part of its functions. It must not be supposed that everything which performed the functions of a diaphragm was a diaphragm in the telephonic sense. To correctly designate a thing a diaphragm it was necessary to consider the context; a sheet of paper by

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itself would not be described as a diaphragm, but when stretched over a pickle pot it was so; "it was a diaphragm when applied for diaphragmatic purposes." Witness did not profess to know how Edison's tension regulator works; the inventor probably does not know himself, but he had made it clear how to produce the desired result. The wooden portions of defendants' instrument constitute a diaphragm in the telephonic sense. It was not to be said that the principle was the same in Edison's transmitter and the defendants', but they were the same thing, although how the result was produced was actually unknown. The carbon pencils and the blocks in defendants' instrument were known as Hughes's microphone. It was not known whether the change in current depended on the change of the facets. In answer to the suggestion that compressibility was essential to all Edison's tension regulators, witness said that he had in former times reported to the owners of Bell's patent (the telephone receiver) to the contrary effect, and those persons had in consequence combined with the plaintiff company. He then explained the essential requirements of a tension regulator to be those of a semi-conductor made of such material as will enable it on the withdrawal of the pressure to return to its previous condition, and thus check the current which had been increased by the pressure.

Re-examined by Mr. MOULTON, Q.C.: The necessary requirements of the diaphragm were clearly described in Edison's specification. The variation of pressure on the carbon blocks in the defendants' patent must necessarily produce variation of pressure contact on the diaphragm.

Dr. Hopkinson was then examined by Mr. MOULTON: He had been well acquainted with Edison's patent for many years. The specification as amended fairly described the invention, and showed a variety of ways of carrying it out. The function of the diaphragm was to gather up the vibrations existing in the air when sound is transmitted, and then to transmit them through the tension regulator so as to cause variation in the resistance of the electrical circuit. That appeared clearly in the specification. He found a diaphragm and a tension regulator in defendants' instrument. The back board was a diaphragm, and so were the whole tube and the base. Edison contemplated in his patent the use of more than one diaphragm. He then described some experiments which he had made with the defendants' instrument, which proved that speaking into the base portion of the transmitter put it into vibration so that it would act on a tension regulator, and so again with the tube without the base, and the wooden board at the back. There were some seven or eight experiments in all which showed, in witness's opinion, that the wooden portion of defendants' transmitter operated as a diaphragm in the same sense as the diaphragm in Edison's invention.

Cross-examined by Mr. BIGHAM, Q.C.: Witness knew Reis's transmitter, which was prior to Edison's patent; the box and tube in that do not produce the effect of a diaphragm in the telephonic sense, although the voice would produce vibration throughout the instrument. It was very doubtful, however, if that vibration would produce any effect on the current of electricity. If an Edison tension-regulator were attached to the mouthpiece, the effect of a diaphragm would be produced. With regard to the experiments, his conclusion was that the wooden board at the back of defendants' transmitter contributed to the diaphragmatic action. In answer to a question as to the cause to which he should attribute the transmission of sound by transmitters of lead, thick wood, and putty, he said he should attribute that transmission of sound, if there was any, to the action of the sound waves upon the carbon pencils. If the defendants' carbon pencils were spoken upon without any wooden surrounding or back, a faint sound might be produced.

Re-examined by Mr. MOULTON, Q.C.: It was well known that sheet lead or even such a mixture as putty would take up acoustic vibrations, but imperfectly.

Sir William Thomson, examined by Mr. ASTON, Q.C.: He had read Edison's specification. His tension regulators as described were novel at the date of the patent. The term "diaphragm" was correctly used by him. It meant a "divider" or "separating thing." A separation was necessary to give rise to differences of the air pressure on the two sides of the divided medium. But for the separation the vibration of the air medium would be blocked. He should not consider that Edison exhausted the substances which could be used for diaphragms; light solid substances were best, such as wood, paper, parchment, aluminium, mica, brass, iron, but things very ill-suited for factors might do for diaphragms. Lead certainly would do, but not as well as wood. Water, mercury, and putty would also do. The question of adaptability of material to the vibrations of the sound waves was entirely one of degree. The essential requirements of a telephonic diaphragm were that it should act rapidly and be as clear and true as possible. The best materials were wood-membranes and elastic metals. He then described some experiments which he had made with the defendants' instrument. He had formed as the result an opinion that the board at the back of defendants' transmitting tube ought to be described as a diaphragm; it did in fact act as a diaphragm.

The case for the plaintiffs was concluded on Wednesday with the evidence of Mr. Imray. He stated that the invention in Edison's transmitter consisted of the combination of a diaphragm or tympan with an electric tension-regulator, that was to say, an imperfectly conducting body, which, when acted on by the diaphragm or tympan, occasions variations of resistance to the electricity passing through, the whole being included in a closed circuit, or complete line of conductor from one pole of a source of electricity, such as a battery, to the other. By a "diaphragm" or "tympan" the witness understood anything that would vibrate in accordance with sound pulses; it must necessarily obstruct those pulses, and therefore separate what was on one side of it from that which was on the other side. A piece of straight-grained wood formed the best diaphragm. It made no difference whether the diaphragm was between the wire and the tension-regulator or *vice versâ*. The witness explained in detail the functions of the diaphragm, and demonstrated the manner in which, in his opinion, the defendants' transmitter infringed the plaintiffs' patent, the diaphragm in their case being found in the sides of the speaking trumpet and its base, as well as in the back board to which it was fastened. Some practical experiments were then carried out, an operator speaking to his lordship through the defendants' transmitter, the voice being directed first directly in front of the instrument, then at the back, and at the side of the tube; then into the trumpet alone detached from the wooden back; then further with the carbon pencils alone fixed on the back board, and without the trumpet; with the carbon pencils suspended in the air by two silk fibres, and connected by two pieces of brass wire; and, lastly, with the board brought up to and again removed from the back of the trumpet during the speaking.

Mr. BIGHAM, Q.C., then opened the case for the defendants by stating that there were three questions to be tried, namely, whether the defendants had infringed the plaintiffs' patent by using a diaphragm within the specification; whether they had used a diaphragm in combination with tension-regulators within the specification; and, thirdly, whether the tension-regulators, as combined with the diaphragm were commercially useful so as to render the patent valid. He then proceeded to contend that the defendants did not use a diaphragm as described or contemplated by Edison, and undertook to demonstrate by experiments that the back board to defendants' instrument did not perform the functions of Edison's diaphragm, and the instrument would work as well without it as with it. Then as to the tension regulators, they were no infringements of Edison's invention.

The hearing of this case was continued on Thursday, and the judgment will be given in our next issue.

COMPANIES' MEETINGS & REPORTS.

The Eastern Telegraph Company (Limited).

The twenty-sixth half yearly ordinary general meeting of the Eastern Telegraph Company (Limited) was held on Thursday, the 16th inst., at the City Terminus Hotel, Cannon-street, John Pender, Esq., M.P., presiding.

The SECRETARY (Mr. George Draper) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN stated that the revenue for the six months ended March, 1885, had been £371,682, being an increase of £26,526 as compared with the corresponding period of 1884. This increase had no doubt been owing to the large number of Press and Government telegrams sent in consequence of the military operations in Egypt and India, and of the war between France and China. The total working expenses had been £91,599, or an increase of £1,117 as compared with the corresponding period of 1884. The general expenses in London had been £1,085 less, but the working expenses at the stations had been £2,959 more. They had opened out four new stations in the half year, namely, at Perim, Piræus, Patras, and Katacolo. There was also a full six months' charge for working the Suakim station against only four months in the same period of 1884. The patent rights of certain inventions of Sir William Thomson—who for the last fourteen years had been receiving a very handsome income from them—were about to expire, if they had not already expired, and that would cause a reduction of £3,000 per annum. In making that statement, however, he ought to say what a great debt they were under—indeed, the whole world was—to Sir William Thomson for these inventions, which had enabled submarine telegraphy to be carried to a point which he believed would not otherwise have been possible. The repairs and renewals of cables had cost £44,815, against £37,113, being an increase of £7,702. The question of repairs had always been an important one, and as their cables were naturally growing older, it must become still more serious, but they had tried in the conduct of their business to maintain their system in as efficient a condition as possible. They had duplicated a very large extent of their system, and they had done a good deal of that duplication and all the repairs out of revenue. They therefore had a very efficient system, but one which required constant care and attention, and it was necessary to have their ships placed at the proper stations, so that they might use them immediately if necessary to effect any repairs. The work done by their ships in the half year had been very considerable. After charging all expenses, including income tax, providing for interest on debentures, debenture stock, and preference shares they were enabled to pay a dividend and bonus of 6 per cent. per annum, and to carry £100,000 to the reserve fund, against £65,000 in the corresponding period of 1884. On the other hand they had written off that fund the discount on the issue of 4 per cent. mortgage debenture stock. Their general reserve fund now amounted to £397,272, and the total reserve funds, including the Sardinian cable and other special reserves, was £431,705. He might state that in 1877 they took £100,000 from the reserve fund in reduction of the cost of new cables; in 1878 they took £13,997 in reduction of the cost of renewals; in 1884 they took £300,000 towards the cost of new cables; and in 1885 they took £28,105 discount on the issue of 4 per cent. debenture stock, or a total of £442,102. Therefore, had the money been kept in the reserve fund, that fund would now amount to nearly £900,000 instead of £431,705. They thought, however, that they had done wisely in the course they had pursued, as it had enabled them rather to increase their traffic, and therefore maintain their dividends. During active times it was absolutely necessary that they should maintain their system in a thoroughly efficient manner. Two or three months ago there was an important scare, which was supposed to have subsided; but on the previous day there was another scare, which had a very serious effect on stocks in the London market. They must have their system in such a condition as to enable them to be

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prepared for scares, come when they might, so as to meet the requirements of the Government, and the telegraphing public. Gibraltar and Malta were two very important strongholds in the Mediterranean, and they thought they ought to have that system especially thoroughly efficient. A considerable amount of the £100,000 now put to the reserve fund had perhaps come out of scares which had occurred rather than from out of legitimate traffic. What they intended now to do was to triplicate the line from the Land's End to Malta, and having done that they would consider the shareholders in a most sound and safe position. He believed this would cost some £300,000; but he believed they would be able to meet that charge partly out of reserves and partly out of other sources in a way which would make their present position more stable. This work they would see was all the more important when he mentioned the breakages which now existed. The following were the cables interrupted:—The Direct Porthcurnow-Lisbon, the Gibraltar-Lisbon, the Suez-Suakim, the Suakim-Perim, and the Bombay-Aden No. 1. They had the thing thoroughly in hand, however, and probably in a week hence they would be in working order again. Meantime, by the arrangements they had made they would be able to earn their income pretty much as if these breakages had not happened. They had occurred since the issue of the report. They had just made an arrangement with the Greek Government, who were very much advanced in their desires for the establishment of submarine telegraphy. The arrangement was for thirty-four years, during which they would receive a subsidy of £6,500 per annum, upon an expenditure of 447 miles of cable.

A SHAREHOLDER: How much money would that be?

The CHAIRMAN: About £60,000 or £70,000. Continuing, he stated that they were now dealing with Turkey, and probably by the time he next addressed them they would be able to say that they had made arrangements for extensions to the Arabian ports of the Red Sea. One would suppose, from the recent craze on the part of Germany and France to possess colonies, that the West Coast of Africa was a sort of Paradise; and it was notorious that the Portuguese Government had invited tenders for a cable to the West Coast of Africa. England had perhaps more important interests there than any other country, and had therefore been obliged to follow suit. He hoped they would be able to report shortly that they had made an arrangement with the British Government in regard to cables in this direction. It was a curious fact that ever since the cable between Zanzibar and Mozambique had been established it had been interrupted every year at much about the same time and place. It appeared that there were two great rivers that ran into the sea at that particular point, and they had now discovered that the cause of the interruption was the great rush of water undermining the land where the cable lay at the bottom of the sea. This cable was, therefore, now being duplicated, and it would cost the South African Company—in which this Company were large shareholders — about £120,000, which would come out of that Company's reserve fund. Next month the telegraph conference would be held in Berlin, and the question of submarine and land telegraphs would then be discussed by the delegates of all the important nations of the world, by whom they had been treated, on the whole, in a fair and reasonable manner, though they were not yet admitted to their councils. There was, however, a feeling abroad now—particularly in Germany, headed by the Telegraph Minister there—that submarine telegraphs should be more or less subordinated to the views and actions and policy of the land lines, and the wish of that gentleman was that there should be a system and a tariff throughout Europe, which would certainly not suit the Company. The cost of a land line and of a submarine line had, however, to be considered, and they maintained that, grand as the land line system was, it did not connect with the world at large, which the submarine cables did. The owners of the latter were therefore, entitled to the highest consideration, and he hoped they would be able to succeed in impressing their views on the delegates at the conference. The system of submarine telegraphy had done a great deal in revolutionising the world, and he hoped they would still further revolutionise the world for good. He concluded by moving the following resolution:—

"That the printed report and accounts of the Directors to 31st March, "1885, submitted to this meeting, be and they are hereby received and "adopted; that a dividend on the Preference shares of the Company to "the 30th June, 1885, at the rate of 6 per cent. per annum be paid, less "income tax; and that, in accordance with the Directors' recommenda- "tion, a dividend be and is now declared of 2s. 6d. per share with a bonus "of 1s. per share, both free of income tax, on the Ordinary shares of the "Company, making, with previous payments by way of dividend on "account, a total payment of 6 per cent. on these shares for the year "ended 31st March, 1885."

The VICE-CHAIRMAN (the Marquis of Tweeddale) seconded the motion, which was carried unanimously, without discussion, and a vote of thanks to the Chairman and Directors brought the proceedings to a close.

[A full report of this meeting will appear in our next issue.]

The Direct United States Cable Company (Limited).

Report of the Directors for the six months ended 30th June last, to be presented to the proprietors at the sixteenth ordinary general meeting, to be held at the Cannon-street Hotel, on Friday, the 24th inst., at 2 p.m.

With this report the Directors submit the usual statements of account for the half year ending 30th June, 1885, which, with the half year's accounts to 31st December last, presented at the ordinary general meeting on the 5th February last, show the financial result of the eighth year's working of the Company. The revenue for the half year, after deducting out-payments, amounted to £36,106. 1s. 1d. against £68,573. 8s. 11d. (after similar deductions) for the corresponding period of 1884, being a difference of £32,467. 7s. 10d. against the half year under review, owing to the operation of the reduced tariff mentioned in the last report. The working and other expenses for the same period, including income tax, but exclusive of cost of repairs of cable, amounted to £17,206. 15s. 11d., leaving a balance of £18,899. 5s. 2d. as the net profit of the half year, making, with £17,251. 2s. 11d. brought forward from the previous half year, a total of £36,150. 8s. 1d. Two quarterly interim dividends of 1½ per cent each, and one quarterly dividend of ¾ per cent., together amounting to £39,461. 10s., have been declared and paid at the usual times during the financial year, and a final dividend of 3s. per share is now proposed, making, with the three interim dividends, 4 per cent. for the year, being a total distribution of £48,568. The appropriation of the above balance of £36,150. 8s. 1d. on the revenue account is thus shown:—

Interim dividend for quarter ending 31st March, 1885	£9,106 10 0
Final dividend now proposed	9,106 10 0
Carried to reserve fund (thereby increasing it to £310,000)..	7,203 13 6
Carried forward to next account.....	10,733 14 7
	£36,150 8 1

A break occurred in our main section of cable on the 27th January last, and was promptly repaired on the 17th February; the cost of the repair, £2,857. 18s. 9d., has been charged against the reserve fund. Our short section of cable is at present interrupted, but the interruption does not affect the working of the traffic, which passes by the alternative land line between Torbay and New York. The repair will be made as soon as possible. Pursuant to the provisions of the Articles of Association two of the Directors, viz.:—The Lord Hawke and Sir Henry Keppel, retire by rotation, and being eligible, offer themselves for re-election. Mr. John G. Griffiths and Mr. John Sawyer, the auditors, retire pursuant to the Articles of Association, and offer themselves for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JULY 15.		BUSINESS DONE WEEK ENDING JULY 15. Highest.		Lowest.	
Anglo-American	27⅛,	28¼	28		27⅛	
Do. Preferred	47,	48	48		47¼	
Do. Deferred	7⅛,	8¼	7¼		—	
Brazilian Submarine	11⅛,	11⅜	11⅜		11 3-16	x.d.
Cuba	11⅛,	12¼	—		—	
Do. Preference	18,	19	—		—	
Direct Spanish	1⅛,	2	—		—	
Do. Preference	12,	12½	—		—	
Direct United States Cable	8¼,	9	9		—	
Eastern Telegraph	11⅞,	12	12 1-16		11⅞	
Do. 6 per Cent. Preference	13¼,	13⅞	13⅞		13 9-16	
Do. 5 per Cent. Debentures, 1899 ..	107,	110	—		—	
Eastern Extension	12⅞,	13	13⅛		12 13-16	
German Union	9¼,	9⅝	—		—	
Globe Telegraph and Trust	7,	7¼	7 3-16		7	
Do. Preference	12⅝,	13⅛	13 1-16		12⅞	
Great Northern	14,	14½	14⅜		14¼	x.d
Indo-European	31,	32	—		—	
Reuter's	7⅛,	8	—		—	
Submarine	185,	195	—		—	
West India and Panama	⅜,	1	—		—	
Do. 1st Preference	8⅛,	8⅜	8¼		8⅛	
Western Brazilian	6¼,	6½	6⅜		6¼	
Western Union 7 per Cent. 1st Mortgage	120,	124	—		—	
Do. 6 per Cent. Sterling Bonds	103,	105	—		—	

TELEPHONES.

Consolid. Telephone and Maintenance..	⅛,	¼	⅛		— x.d.
Oriental	⅛,	⅜	—		—
United Telephone	11½,	12	11⅞		11¼ x.d.

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)..	1⅛,	2	1⅞		—
Do. (fully paid)	3⅛,	3⅞	3¾		3⅛
Hammond Light (£3 15s. paid)	⅛,	⅜	—		—
Swan	⅜,	⅜	—		—
Maxim-Weston	⅛,	¼	—		—

MISCELLANEOUS.

Telegraph Construction	35½,	36½	37		36¼
India Rubber, Gutta Percha, and Telegraph Works	24½,	25½	25		24½

TRAFFIC RECEIPTS FOR JUNE, 1885.

COMPANIES.	June, 1885.	June, 1884.	Increase.	Decrease.
Brazilian Submarine	—	—	—	—
Cuba Submarine	3,000	3,168	—	168
Direct Spanish Telegraph ..	1,333	1,336	—	3
Direct United States	—	—	—	—
Eastern Extension	37,846	37,585	261	—
Eastern Telegraph	—	—	—	—
Great Northern	24,840	—	—	—
West Coast of America	4,200	—	—	—

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NOTES.

NOTICE OF REPAIR.—The cables of the Western Union Telegraph Company are now repaired.

NOTICE OF INTERRUPTION.—The cables between Suez and Suakim and between Perim and Suakim are interrupted.

BARCELONA.—The Barcelona Exhibition will be inaugurated in the month of September, 1887, and will remain open until April, 1888.

THE MILDE TELEPHONE.—In a recent issue of our contemporary *L'Electricien* an interesting article is given upon the Mildé Telephone.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 17th inst. were £2,997.

THE TELEGRAPHS BILL.—The House will probably sit to-morrow (Saturday), in order to forward the Telegraphs Bill and other measures.

AN AERIAL ELECTRIC RAILWAY.—It is proposed to construct a small aerial railroad in Paris, on the American model, the motive power being supplied by electricity.

A NEW CONTEMPORARY.—We have received the first issue of the *Revue Internationale de L'Electricite et de les Applications*. We wish our young contemporary every success.

APPOINTMENT.—We understand that Mr. Melhuish, late of Siemens Brothers, has been appointed resident engineer to the Imperial and Continental Gas Association of Vienna.

THE ELECTRIC LIGHT IN QUEENSLAND, AUSTRALIA.—A preliminary trial of the electric light, which has recently been made in the Parliament Buildings, gave great satisfaction.

SAW-DUST FUEL.—One of the electric lighting companies in America now uses saw-dust for fuel. It finds this fuel, we are informed, more economical than screenings for making steam.

VOLK'S ELECTRIC RAILWAY.—The Town Council of Brighton, at a recent sitting, decided to allow the electric railway to remain on the beach on terms more favourable to the Corporation.

GETTING ROUND THE CLIMATE.—In Algiers they are making use of the electric light for harvest operations at night. The climate is such that no European can work during the day time.

THE PERSIAN TELEGRAPHS.—A telegram from Teheran says that telegraphic communication between Teheran and Meshed is very unsatisfactory. The line is working badly, and frequently breaks.

BOOKS RECEIVED.—"Electric Lighting," "The Catalogue of the Kinetic Engineering Company," "The National Telephone Company (Limited) List of Subscribers in the Edinburgh District for July."

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th July are £2,529, as compared with £3,141 in the corresponding period of 1884.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending the 17th inst. were £2,287, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

A NEW LIGHTNING CONDUCTOR.—Mr. Hubbell, of Washington, has conducted some successful experiments with a new lightning conductor, which has been designed with a view to the efficient protection of the immense reservoirs of oil which are exposed to the atmosphere in the vicinity of that city.

THE ELECTRIC LIGHT IN PAISLEY.—The Edison and Swan Company are now working on another installation of about 800 lamps for Messrs. J. and P. Coats, Paisley. This is the third installation for the same firm secured by the Scottish branch of that company before it was broken up in May last.

A LARGE GALVANOMETER.—There has just been completed at Cornell University the largest galvanometer in the world. It has been built under the direction of Prof. William A. Anthony, of the department of physics, and over a year was spent in its construction. It has four circles, each two metres in diameter.

LOWESTOFT.—At a recent meeting of the commissioners of this town a communication was received from Messrs. Laing, Wharton, and Down, electrical engineers, London, offering to treat with the commissioners for introducing into the town their system of arc lighting, which had been received with so much favour in the United States and at the Inventions Exhibition.

THE ELECTRIC LIGHT IN MILAN. — The work of installing the electric light in the offices of the President of the Giunta and the various other offices of the municipality of Milan is being proceeded with. The contract, which is for five years, and which comes into operation on the 1st of next September, has been obtained by the Società Generale di Elettricità.

LITERARY ANNOUNCEMENT.—We understand that Mr. Alexander Watt has been for many months engaged in writing a comprehensive practical treatise on the electro deposition of metals, including the electrolytic refining of copper and other metals and treatment of ores. The work, being now complete, will shortly be in the hands of the public. The publishers will be Messrs. Crosby Lockwood and Co.

FIRE IN AN ELECTRIC SHOP.—At a quarter to 1 o'clock on Wednesday morning a fire broke out in one of the lockers in the electric shop in the Portsmouth Government dockyard, supposed to have been caused by the spontaneous ignition of some waste which had been stored there. The building is constructed of corrugated iron, and the fire being confined to the lockers little damage was done.

THE ELECTRIC LIGHT IN VIENNA.—The Imperial Gas Association in Vienna have, we are informed, decided upon the establishment of a central electric lighting station at which sufficient current will be generated to aliment 12,000 sixteen candle-power incandescent lamps. The installation at the central station will consist of four steam engines of 200 horse-power, four dynamos and 9,600 accumulators.

NEW ELECTRIC LAUNCH.—The Electrical Power Storage Company are building an electric launch for the Duke of Bedford, to be used in connection with his steam yacht, the "Northumbria." The launch will be 28ft. long, and will be suspended from the davits, the accumulators being used in connection with the existing electric lighting of the yacht when they are not required for the propelling of the launch.

HOLIDAY MAKING. — On Saturday last the officials and *employés* in connection with the establishment of Messrs. Walter T. Glover and Co., of Salford, to the number of 121, paid a visit to Blackpool, where they were indulged in a round of gaieties. Free tickets of admission to the Winter Gardens

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and the Aquarium, as well as an excellent breakfast and dinner, were provided by the firm, who also defrayed the railway and other charges incidental upon the journey.

THE ALBERT PALACE, BATTERSEA.—The installation at the Albert Palace, Battersea, comprises nineteen 2,000 candle-power Brush arc lamps distributed in the gardens and nineteen Victoria incandescents. The current is supplied by two Brush dynamos of the old type driven by a 12 horse-power semi-fixed Robey engine. We are informed that it is the intention of the management to add to this installation at an early date a further number of 650 incandescent lamps.

A SERIOUS FIRE.—A fire which broke out on the night of the 16th inst. at Washington destroyed the building occupied by the offices of the *Washington Post*, the *Washington National Republican*, the *Washington Critic*, and the *Sunday Gazette*, and by those of an electric light company, besides destroying property valued at 150,000 dols. Every lamp connected with the electric light company's office was extinguished, leaving some portions of the city in comparative darkness.

FATAL ACCIDENT.—On the afternoon of 30th June, in West Indianapolis, a foolish person, for a trifling wager, climbed to the top of an electric light tower, 120ft. high. He attempted to descend by means of a guy rope, but his grip on the rope was lax and he descended at such speed that the friction caused him to relax his grasp, when he fell to the ground, 70ft. In falling his body struck some telephone wires, turning him head downward, and he fell on his head and shoulders, fatally injuring himself.

DOMESTIC LIGHTING IN BELGIUM.—*La Chronique des Travaux Publics*, in a recent issue, gives an account of an installation which has been put down in the Château du Rond-chêne, the residence of M. Montefiore-Levi, who is said to be an ardent promoter of electrical science. This comprises an 18 horse-power engine, driving a Victoria and a Gramme dynamo. These supply current to 300 20 candle-power incandescent lamps, which light the whole of the rooms, staircases, corridors, and offices of the château.

TELEGRAPHIC COMMUNICATION WITH BARRA.—Telegraphic communication was opened to Barra about the beginning of last September, but it seems that during the herring fishing one wire along the whole system is wholly inadequate for the business of the place. The result is that a special wire for Barra is now being erected from Lochbeisdale to Lochmaddy, and possibly to Stornoway; so that in future messages can be sent direct to these places without interfering with the business of the intermediate telegraph stations.

ANGLO-AMERICAN TELEGRAPH COMPANY.—At a meeting of the Board of Directors of this company, held on the 21st inst., it was resolved, "After placing the sum of £12,500 to the Renewal Fund, making £50,000 for the half year, to declare an interim dividend for the quarter ending 30th June, 1885, of 6s. per cent. on the Ordinary stock, and 12s. per cent. on the Preferred stock, less income tax, payable on the 1st August to the shareholders registered on the books of the company on the 17th July, 1885."

AN ANTI-HOAX FIRE ALARM.—An ingenious individual, Mr. E. Jungerman, of Gettyburg, Pa., has invented a new system of fire alarm apparatus, which, if adopted, will put a stop to the little games of certain misguided people who think it a good joke to raise fury in the breasts of too patient firemen. This device compels the sender to the alarm to remain in a box until the arrival of the person or persons summoned. A very good idea we think, for no charitable person would surely object to be boxed up, in so good a cause, for a few seconds.

ELECTRIC LIGHTING OF TRAINS.—On the occasion of the visit of H.R.H. the Prince of Wales to Preston, Lancashire, the Royal train was lighted by electricity. Two head-lights were used, each of 50 candle-power, and forty 20 candle-power lamps were distributed in the saloons, &c. These were the Woodhouse and Rawson 40-volt pattern, and were supplied from E.P.S. accumulators. The fittings and electroliers, we are informed, were of the most elaborate description. H.R.H. the Prince, the Duke of Sutherland, and others expressed great satisfaction with the light.

LONG DISTANCE TELEPHONY IN AUSTRALIA.—In connection with telephonic communication, a very interesting series of experiments has been carried out lately by Mr. Parsons, the Telegraph Station Master at Albury, with Melbourne and Sydney. An extra thick wire, which had been laid down along the distance between the two capital cities, was used, and between Melbourne and Albury the result was most satisfactory. Voice-speaking at Melbourne, 187 miles away, was clearly and distinctly heard at Albury, the identity of the speaker being easily recognisable.

ASSOCIATION FRANCAIS POUR L'AVANCEMENT DES SCIENCES.—The next session of this association *(Congrès de Grenoble)* will endure from the 12th until the 20th of August, 1885, inclusive. Amongst the questions which will be treated in the physical and chemical sciences group we notice the following:—A new method for the determination of magnetic movements, by M. J. B. Baille; the application of condensers to electro-physiology and electro-therapia, by Dr. Baudel; a new induction coil, by Dr. Dagrève; measurement of electric resistances, by Prof. Hurion; India rubber, by M. Roussel, &c.

ICEBERGS IN FOG.—Some recent experiments show that echoes may be plainly heard at sea, even when the object sending back the sound is a mile away from the source of the sound. It is suggested, therefore, that icebergs might be detected at sea and avoided if shots were fired periodically from the bow of a steamer or other vessel. Mr. Della Torre, who originated this method, claims that a steam whistle or siren, combined with a projecting apparatus like a speaking-tube, will serve as efficiently as a gun. Prof. A. G. Bell has taken great interest in the method, and has conducted the experiments establishing its feasibility.

THE ELECTRIC LIGHT AND PHOTOGRAPHY.—Some experiments took place at Woolwich Arsenal on Saturday with a view of testing the practicability of photographing the interior of guns by means of the electric light, so as to detect flaws during their manufacture or cracks after firing. Two 8in. muzzle-loading guns formed the subject of the test. The light was introduced a short distance within the muzzle, and reflected down the bore by means of a mirror, the photograph being taken from the breech end. The light produced by a dynamo was not quite so steady as that from a primary battery or accumulators, but both gave good results.

ELECTRICITY AND WARFARE.—Some interesting experiments were carried out during the course of last month at Schœneberg, near Berlin, with a view to the application of the electric light, in conjunction with captive balloons, to the purposes of military reconnaissances. A balloon, provided with an arc lamp, was elevated to a height of about 200 feet, and upon the light being projected by means of a powerful reflector sufficiently satisfactory observations of the country in the immediate vicinity were made. The lamp was supplied with current by a Siemens dynamo; and telephonic communi-

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cation was maintained between the car of the balloon and the earth.

ELECTRIC SIGNALLING BALLOON.—On Monday evening last a number of gentlemen assembled in the gardens of the Albert Palace at Battersea to witness a trial of a new system of electric signalling from balloons, devised by Mr. Eric S. Bruce. The novel feature of this invention is the introduction of incandescent lamps in the body of the balloon. On the occasion referred to, six 16 candle-power Swan-Edison lamps, fed by twenty-four E.P.S. accumulators, were placed inside a captive balloon of translucent material, and after it had attained to a height of about 200 feet from the ground, signals by means of the Morse code were conveyed at a speed of four or five words per minute to a supposed friendly force at a distance of some ten or fifteen miles from the scene of operations. The invention promises to be a valuable one.

TELEPHONIC COMMUNICATION AT THE MARRIAGE OF PRINCESS BEATRICE.—In order that direct telegraphic communication may be had with Her Majesty's royal yachts in Cowes Bay, to enable them to immediately carry out sudden orders from Osborne House a telephone wire has been recently laid down from the billiard room in the royal residence to the royal landing stage, East Cowes, off which lie at anchor the "Alberta," "Victoria and Albert," and other royal yachts. The telephone was first used on Wednesday morning last, when Her Majesty inspected the Camel Corps, and has been found to work admirably, and to be of the greatest possible use. The telephonic appliances consist of Johnson's patent transmitter and Bell's patent telephone, and have been supplied by Messrs. Tasker, Sons, and Co., of Sheffield.

ELECTRIC LIGHTING IN DYE HOUSES.—Owing to the prevalence of steam in dye houses, some difficulty has been experienced in adapting the electric light to the peculiar conditions which are required. This difficulty, however, seems to have been overcome, and, considering how necessary it is that the dyer should be able readily to distinguish the various colours he has in hand, it is not an unimportant achievement. Messrs. J. Bannister and Sons, dyers, of Leeds, have recently introduced the electric light into their works, and have obtained a satisfactory result. The lamps used are the Pilsen arc of 1,000 candle-power each, and they are run from a Phœnix dynamo, made by Messrs. Paterson and Cooper, at their steam factory, Pownall-road, Dalston. The installation was carried out by their representative, Mr. Wilson Woodhead, Royal Exchange, Leeds.

THE "CASSEL" PROCESS.—On Friday last experiments on a large scale were made at the works of the Cassel Company in Verulam-street, London, to demonstrate the efficacy of their process for the treatment of refractory gold and other ores. Amongst those present were Mr. J. E. Spagnoletti, President of the Society of Telegraph-Engineers and Electricians; Professor George Forbes; Dr. Hugo Miller, F.R.S.; Mr. Warren De La Rue, F.R.S.; Sir Hussey Vivian; Mr. J. Arthur Phillips, F.R.S.; Sir Hugh Low; Sir Charles Tennant, Bart., Chairman of the Cassel Company; Col. Sir Francis Bolton, and others. The point of interest in this process is the introduction of lime to effect the precipitation of the iron in solution. The experiments, which were conducted by Mr. Henry R. Cassel, the inventor, Dr. Henry Liepmann, F.C.S., and Dr. Rowland J. Atcherley, F.C.S., gave great satisfaction.

THE MECHANICAL TELEPHONE.—Under the designation of "The Mechanical Telephone," says a non-technical contemporary, a new instrument has just been brought to this country from America, and was tested in London last week. This telephone does not require electricity, but, as its name implies, is purely mechanical. Its construction is simple, and consists of a diaphragm or sounding board made of strips of willow wood closely interwoven together and varnished. This wood is found to possess a high degree of sensibility to sound vibrations. In the centre of the diaphragm is fixed a disc of metal from which the communicating wire passes to any point desired up to two miles. The instrument, being enclosed in a small wooden case, can be easily fixed, and remains ready for use, requiring no attention of any sort. Various methods were adopted to try the utility of the instrument, and in all cases it fully met the demands made upon it.

THE EARTHQUAKES.—A Reuter's telegram, dated Bombay, July 18, says that a severe shock of earthquake occurred on the day previous at Murree, but without causing any serious damage. No one was injured. Shocks of earthquake are also reported from other parts of the Punjaub. Another telegram from Simla, dated July 17, announces that during the last few days there has been a recurrence of earthquake shocks in Cashmere. The total loss of life by the recent earthquakes in Cashmere is officially estimated at 3,081. Upwards of 25,000 sheep and goats and 8,000 cattle were killed, and 70,000 houses were laid in ruins. Subsequent to the above twelve shocks of earthquake, one of which was very severe, were felt in Cashmere. This was on the 16th inst. A telegram from Teneriffe announces that a shock of earthquake was felt there on the morning of the 22nd instant. No details had been received up to the hour of our going to press.

THE PROPOSED ALTERNATIVE CABLE TO THE CAPE.—On June 18, at Cape Town, Mr. Sprigg (on behalf of Mr. Upington) moved that the House go into committee to consider the following resolution:—"That the Government be authorised to enter into negotiations with the India Rubber and Gutta Percha Company, of Silvertown, or other suitable company, for the purpose of securing an alternative line of cable communication between the colony and England, *viâ* the West Coast of Africa, provided the amount of subsidy payable annually does not exceed the sum of £——." Mr. Sprigg said that the honourable Attorney-General would be able to explain to the committee, when he was in the House, what prospect there was of obtaining an alternative cable. He moved that the House go into committee on June 22, which was agreed to. It would seem, however, that this had not been done, owing, perhaps, to the long debates which had taken place upon the estimates.

A REMARKABLE PLANT.—A recent German publication contains a description of a new electric plant that has been christened Phytolacca electrica, which possesses strongly marked electro-magnetic properties. In breaking a twig the hand receives a shock that resembles the sensation produced by an induction coil. Experiments made on this plant showed that a small compass was affected by it at a distance of about 20ft. On a near approach the needle vibrated, and finally began to revolve quite rapidly. The phenomena was repeated in reverse order on receding from the plant. The energy of the influence varied with the time of day, being strongest at about two o'clock p.m., and becoming almost nothing during the night. It was also greatly increased in stormy weather; and when it rains the plant seems to wither. It is said that no birds or insects are ever seen on or about this plant. The soil where it grew contained no magnetic metal like iron, cobalt, or nickel, and it is evident the plant itself possesssed this electrical property.

THE ELECTRIC LIGHT IN TURIN.—The installations which are to be put down in Turin by the National Company for the

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distribution of electricity by secondary generators and by the Società Italiana del Gaz will, as far as the lamps are concerned, be located as follows: Piazza Vittorio: exterior, 12 arc lamps of 1,000 candle-power, and 50 incandescent lamps of 50 candle-power each in the doorways; Via Po: 10 arc lamps of 800 candle-power, and 50 incandescents of 50 candle-power in the doorways; Piazza Castello: 4 arc lamps at the corners of the Palazzo Madama, of 5,000 candle-power each, and 30 incandescent lamps of 50 candle-power in the doorways; Galleria Subalpina: 2 arcs of 800 candle-power each; Via Roma: 40 incandescent lamps of 50 candle-power; Piazza San Carlo: exterior, six 800 candle-power arcs, and 10 incandescent lamps of 50 candle-power in the doorways; Via Garibaldi: 12 arc lamps of 800 candle-power at the corners of the streets; Piazza dello Statuto: 8 arcs of 800 candle-power, and 30 incandescents as before; Piazza del Palazzo di Citta: 2 arc lamps of the same kind as the preceding, and 5 incandescents in the doorways.

New Telegraphic Cable to Shetland.—On Tuesday last week, as notified in our last issue, operations in connection with the new telegraphic cable from Aberdeen to Shetland were successfully completed, and communication between these places may now be said to be satisfactorily established. Meanwhile, the work is being conducted by the single process, but it is expected that the duplex principle will shortly be introduced. The line was decided on by the Department after careful investigation during the winter, and its object, as mentioned in our last issue, is to facilitate the business of the herring trade, which is now commencing for the season all along the north-east coast. The cable ship "Monarch" has been employed in the work for the past three weeks. The total length of the line is about 300 miles. The advantage of the new arrangement is that direct communication can now be had between Shetland and London with only one retransmission, namely, at Aberdeen. There were formly three transmissions—Edinburgh, Inverness, and Wick—and the great benefit of the telegraphic facilities now afforded is obvious.

The Electric Light in Brooklyn, U.S.A.—The Municipal Electric Light Company, of Brooklyn, opened a new station recently at 306, Penn-street, and also lighted a large portion of the Eastern District for the first time under the provisional contract with the city. The lighting was, we are informed, admirable. The new station is of brick and substantially built. The dimensions of the building are 60ft. by 100ft. In the basement in front on one side are three furnaces and boilers. These are each 8ft. by 16ft., and each boiler contains eighty-four 3½ inch tubes. On the same side of the building on the ground floor are five Buckeye engines. Four of these are 6in. by 14in. and have a capacity of 60 horse-power, and the other is 11 × 16in., and has a capacity of 150 horse-power. Connected with these by belts are 10 dynamos. The total capacity of the present machinery is about 400 lamps of 1,200 candle-power each. The engines are set upon solid masonry, and there is no vibration when all the machinery is in motion. Only one side of the building is now occupied, making it possible to double the capacity of the works.

Lamp Shades.—The subject of the degree in which lamp shades serve to abstract light, or to increase illumination at certain points, has been taken up by Prof. H. L. Cohn, in Germany, who recently described a long series of determinations of the relative values of various forms of lamp shades. The method pursued was to measure the brightness of white paper lying on a table over which the source of artificial light was suspended at a given distance, by means of a Weber photometer. As one would anticipate, the general effect of a shade is to increase very greatly the illumination immediately under the light, and not to modify it notably at an angular distance greater than forty-five degrees from this region. Taking as a measure of the value of the illumination the number of lines which can be read from a newspaper in a minute, and as the unit of illumination that of a normal candle at a perpendicular distance of a metre from the paper, he finds that the best illumination is not less than fifty such units. Since even a fifth of this illumination is very rarely secured, except immediately under a lamp provided with a good shade, he emphasizes the conclusion that few persons work in a satisfactory light.

The Post Office Telegraphs.—According to the Postmaster-General's annual report, the telegraph business of the country shows but little development, and an increase of only 435,000 messages in the year cannot be regarded as satisfactory. The yearly increase has, owing, no doubt, to the stagnation of trade, the competition of the telephones, and the rapidity of the letter post, been steadily diminishing during the last five years. The expenditure has, however, largely increased, and it will be noticed that last year it exceeded the revenue by about £36,000, and that for two years no contribution has been made towards the payment of the interest, amounting to £326,417 a year on the capital invested. The department has at present twenty-seven telephone exchanges open in various country towns, with a list of 1,141 subscribers paying a total of £22,600 a year, but by far the greater part of the telephone exchange business of the country continues to be conducted by private companies, who now obtain licenses from the department on the very liberal terms laid down in August, 1884. The royalties paid by companies amounted to only £19,370 in the year. The full effect of the telephonic competition with the telegraphs remains to be seen, but the Postmaster-General cannot doubt that the telegraph revenue has been and will be adversely affected.

Electric Light at the Mansion House.—Mr. G. Offor has written to the *City Press* as follows:—"'Another failure of the electric light at the Mansion House' is calculated to prejudice the public unless it is explained that such failures can be absolutely prevented by the use of storage batteries, without which no system of incandescent lighting is perfect. All installations of importance are now being made with the aid of storage batteries. Among those successfully working in the City, I need only refer to the Bank of England, Peninsular and Oriental Steam Navigation Company, Messrs. F. Huth and Co., Messrs. A. Gibbs and Sons, Messrs. Spink and Son, Messrs. Foster and Braithwaite, Messrs. Johnson, Matthey, and Co., the Falstaff Restaurant, the Consolidated Electric Company's offices and factory. This company tendered to light the Mansion House with 520 lamps of 20 candle-power, entirely from storage batteries, but I presume that the General Purposes Committee, in giving the contract to the Hammond Company for their system of direct running, were actuated solely by an apparent economy, sacrificing the most important element of thorough efficiency. In so important a public building as the Mansion House, the first consideration should be to obtain a light that can be depended upon for not going out just when most needed, and an artistic arrangement of the lamps is also very essential. When the Mansion House was first lighted it was with wretched arc lamps, in the style of a railway station or iron foundry, and the present display is far from suitable to the civic palace."

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THE ELECTRIC LIGHTING ACT.—The Board of Trade have just presented to Parliament a report on the subject of the applications made to them under the provisions of the Electric Lighting Act of 1882, during the past year, and their proceedings thereon. From it we learn that only one application for a Provisional Order was received up to the 21st of December last; and this was from the Chelsea Electricity Company (Limited), who asked for power to light a portion of the parish of Chelsea. The report states that this order has not been proceeded with. Since the date of the last report, the Board have revoked the whole of the Provisional Orders (fifty-five in number) granted to companies in the session of 1883, with the exception of the Birmingham order, the provisions of the orders as to the appropriation and deposit of capital not having in any case been complied with. With regard to the orders granted in the session of 1884, the Board have received applications for their approval of an extension of the time within which the deposit of capital should be made in respect of the Fulham District Electric Lighting Order, 1884, granted to the West Middlesex Electric Lighting Company; and of the St. James, St. Martin, and St. George, Hanover-square (West London) Electric Lighting Order, 1884, granted to the West London Electric Lighting Company. In each of these cases the Board (after consulting the local authorities) approved of an extension of the time until July 3, 1885. In the case of the first-mentioned order, an application for approval of a further extension of time has been received, and is now under consideration. Since their last report the Board have received applications for two licenses; and they are now under consideration. One was made by a local authority (the Dalton-in-Furness Local Board), and the other by Mr. J. E. Veale, of St. Austell.

ELECTRIC LIGHTING OF PUBLIC BUILDINGS.—The Exeter Town Council are erecting a new lunatic asylum, under the supervision of Mr. Wilkinson, architect, of that city, and for a considerable time the question of the lighting of the buildings has been under consideration. Some months ago the Council declared in favour of the adoption of the electric light, and at their last meeting, held a fortnight ago, this decision was reaffirmed. Several tenders to install the electric light have been sent in, and the architect has presented a report on the tenders, based on the calculation that a light of 8,000 candle-power would be sufficient. The tenders received from companies not using storage batteries were as follow:—J. D. Andrews and Co., Glasgow, capital to be sunk £2,490, total annual cost £768; F. Geere Howard, London, capital £3,210, annual cost £347. 16s.; Walker and Olliver, Cardiff, capital £2,310, annual cost £722. 4s.; Simplex Company, Manchester, capital £3,086, annual cost £467. Companies using storage batteries:—Anglo-American Brush Company, capital £2,410, annual cost £541. 4s.; the Consolidated Electric Company, capital £1,735, annual cost £339. 17s.; Gulcher Company, capital £2,960, annual cost £578. 4s.; Woodhouse and Rawson, capital £2,426, annual cost £527. The latter tender was for 6,000 candle-power. It will be observed that the estimate and absolute annual tender for maintenance of the Consolidated Electric Company is the lowest. This company proposed to do the greatest amount of work with a large storage battery, which it is claimed would give a more even-current and steadier light than if the electromotive force was supplied direct from the dynamos. A week or two ago a deputation, consisting of several members of the committee having charge of the asylum arrangements, went to London to inspect the various installations there. They gave details at the last council meeting of inspections they had made of the electric lighting at First Avenue Hotel, Holborn, the Criterion Theatre, Gatti's Restaurant, the offices and factory of the Consolidated Electric Company, Cow Cross-street, E.C., the premises of Spink and Son, Gracechurch-street, the Inventions Exhibition, the Bank of England, the offices of the Peninsular and Oriental Steamship Company, Messrs. Swan and Edison's works, Holborn Viaduct, Messrs. Andrew and Co., High Holborn, the Holborn Restaurant, the Savoy Theatre, the Law Courts, the Stock Exchange, the Crystal Palace, and other places, and the committee considered "the electric light, from a proper installation, is brilliant, reliable, perfectly safe, and under complete control." At the next meeting of the council the committee will recommend one of the tenders above mentioned for acceptance.

SUGAR REFINING BY ELECTRICITY.—In reply to many of our readers who are anxious for further information upon this subject we publish the following statement, which has been forwarded to us by Mr. J. U. Robertson, 5, Baltic-buildings, Redcross-street, Liverpool, on behalf of the Electric Sugar Refining Company, of New York. This gentleman says:—"Cable advices to myself and others in Liverpool have just been received from several gentlemen who were present at the demonstration of this company's process of refining sugar, which was given on the 15th inst., in New York, on a scale much larger than has heretofore been attempted. The result was most satisfactory, for in the short space of seven hours some 40 barrels of refined sugar were produced from a common grade or ordinary West Indian refining sugar, without making any syrup or soft sugars, the whole product being the highest grade of refined sugars, the analysis of which exceeds 99·50 per cent. cane sugar. The conditions upon which this demonstration was to be given (as per my letter advices received previously) were to be as follows:—(1) Five to six tons raw sugar were to be refined at one time; the same to be carefully weighed and analysed; the analysis to be by Professor Chandler, of Columbia College, New York, who is a well-known public analyst. (2) The premises in which the machine stood to be thoroughly examined by the gentlemen present, to see that no sugar was there except the raw which had been brought to be refined. Every precaution to be taken to see that no communication from without was possible. (3) This done, they should certify the same in writing, and then the work of refining would commence and continue, they being in and around the premises during the time occupied. (4) The inventor undertakes, as a condition of the demonstration, to return them refined sugar of such sizes as they may designate before the demonstration, and to give them in weight of refined sugar within one per cent of the weight of the entire saccharine matter in the raw sugar, including glucose or invert, as shown per the analysis of Prof. Chandler, and he also undertakes that the said refined sugar will analyse not less than 99·50 per cent. cane sugar. (5) These things being performed, the demonstration was to be considered conclusive and satisfactory in every particular. The reason for giving this demonstration, which is one of many, is to secure from the sale of shares the balance of the capital required to complete the machinery and put it into operation, and I am advised that sufficient have been contracted for, pending this demonstration, to furnish that, including a small number of shares which have been placed in my hands for that purpose. I am also advised that the machinery to refine 500 tons of sugar per day of twenty-four hours is far advanced in its construction, and will now be pushed forward to completion. Mr. Robertson adds that he will be happy to supplement this information if desired, and also to show samples of the sugar produced by the company's process.

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ON THE DESIGN AND CONSTRUCTION OF DYNAMOS.

BY GISBERT KAPP.

(Continued from page 25.)

The starting point for determining the number of lines created by a certain exciting power, P, is Ampère's theory of electro-magnetic action, according to which a closed plane circuit traversed by a current is equivalent to a magnet, the axis of which is at right angles to the plane of the current, and the magnetic moment of which is numerically equal to the product of current into area enclosed by the conductor. The moment of a magnet is the product of strength of pole and length. If we assume the magnet to be a very short cylinder, having for base the contour of the current, it becomes a magnetic shell, and we can also say that the magnetic action of a closed current is equal to that of a magnetic shell of the same contour. It is not necessary that the shell be in a plane; it may form part of a curved surface, but its contour must coincide with the current. It is also not required that its two end faces be parallel, though this is the simplest case applicable to straight bar magnets; but it is necessary that the density of magnetic matter distributed over the end faces should in every point be inversely proportional to the distance between the end faces at that point. A magnetic shell may therefore be wedge shaped, and by assuming a number of such shells put together we can obtain a curved magnet. If the shells are all magnetised the same way—that is to say, if the contiguous end faces of neighbouring shells contain equal amounts of magnetic matter of opposite sign—they will all neutralise one another, and the magnetism on the free end faces of the first and last shell only remains.

Imagine we have n such shells put together so as to form a horse-shoe magnet, with parallel pole faces a distance d apart. The number n can be chosen without any other limitation but this, that it shall be sufficiently large to make the thickness of each shell very small. We can therefore choose n to be equal to the number of turns of wire wound on our horse-shoe magnet, and if C be the current in this wire (given in absolute measure, viz., amperes $\times 10^{-1}$) the magnetic moment of each shell will be C S, where S is the area enclosed by the current. We have hitherto tacitly assumed that all the shells are equal in outline and thickness, or in other words that the cross section of our horse-shoe magnet is the same in all places. This is not necessarily the case; if the cross section of the magnet varies gradually, the density, σ, of magnetic matter spread over each face of a shell will also vary gradually, so that the total amount of magnetic matter σ S remains constant and the magnetism of contiguous shells will still be eliminated, leaving only the first and last face covered with magnetic matter. But if the cross-section should vary in an abrupt manner, which would be the case if the magnet were composed of straight slabs put together at right angles with projecting corners, this continuity would of course be interrupted and a certain amount of free magnetism would be noticeable at the corners and at other intermediate points. We might express this by saying that whilst in the perfect magnet the lines of force leave and enter the system of shells only at the end faces, in the imperfect magnet a certain number of lines pass out or in at intermediate points. It need hardly be pointed out that a perfect magnet, such as we have described, is only a mathematical conception and connot be found in nature. To make it possible it would be necessary that the iron offer absolutely no resistance to the lines of force, and that it have no saturation point—in other words, that there should be no limit to the number of lines which one square inch of iron can accommodate. But although no such magnet is possible, it is convenient to regard it as an ideal standard of perfection with which the magnets practically possible might be compared.

The total magnetic moment of the n shells is evidently n C S, and this by the definition above given must be equal to the product of strength of poles by their distance. In the case under consideration the poles are not two mathematical points, but two surfaces charged with free magnetic matter to the total amount $\pm \sigma$ S. For the sake of simplicity we assume the surface density of distribution to be constant, and the two surfaces to be parallel to each other, and separated by an air space, d (Fig. 16.) The magnetic moment is therefore σ S $d = n$ C S.

To find the intensity of field within the air space we must first determine the total number of lines passing across, and then divide that number by S. We have defined unit field that where there is one line of force to every square centimetre (*see* p. 512, Vol. XIV). If we have a free magnet pole equal to unity it will be urged along in the direction of the lines in a unit field with the force of one dyne. Now assume we have a fixed unit pole, and we describe around it as centre a sphere with a

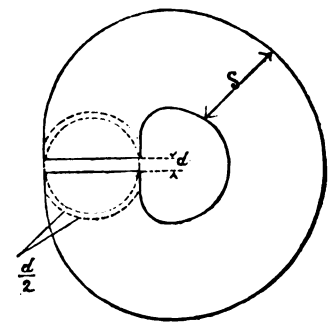

Fig. 16.

radius of one centimetre; then, if we bring another unit pole of opposite sign on to the surface of this sphere, it will be attracted towards the centre with the force of one dyne. We may shift the position of the second pole on the surface without doing any work and without increasing or decreasing the attraction. In this respect the case is similar to that of a unit pole moved in a plane which is at right angles to the lines of a uniform field. If the force which tends to lift the unit pole out of this plane is one dyne, we express the strength of the field by saying that to every square centimetre of surface there is one line of force. Similarly there must be one line of force to every square centimetre of surface on the sphere described around our fixed unit pole, and since the surface of a sphere of radius 1 is 4π, we find that the total number of lines radiating from a unit pole is 4π. If the amount of free magnetism at the pole instead of being unity were σ S, the total number of lines would evidently be

$$Z = 4\pi\sigma S.$$

In this equation σ S can be replaced by its value resulting from the former equation, and we find

$$Z = 4\pi \frac{n C S}{d}.$$

The density of lines per square centimetre, or the intensity of field, is the ratio between Z and S.

$$I = \frac{4\pi n C}{d}.$$

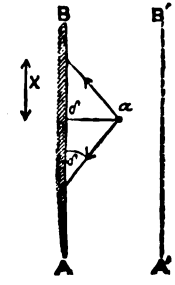

Fig. 17.

An objection might be raised regarding the validity of this formula on the ground that $4\pi\sigma$ S is the total number of lines radiating from a point in which σ S units of magnetic matter are concentrated, whereas in our case this quantity is spread over the surface S; and what holds good for a point need not

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necessarily hold good for a surface. A somewhat more rigorous proof is therefore desirable. Let in Fig. 17 a be a unit pole, placed at a distance δ from the polar face A B, over which magnetic matter is supposed to be equally distributed with a surface density σ. An elementary ring $2\pi x\,dx$ attracts the pole in the direction of the arrows with a force $\frac{2\pi x dx.\sigma}{\delta^2+x^2}$, this force being distributed over a cone which intersects the plane A B at the angle α. The vertical resultant of the attraction is therefore $2\pi\sigma\sin\alpha\,\frac{x\,dx}{\delta^2+x^2}$.

Substituting for x $\delta\,\frac{\cos\alpha}{\sin\alpha}$ and for dx $\delta\,\frac{d\alpha}{\sin^2\alpha}$ we obtain the vertical attraction due to the elementary ring

$$2\pi\sigma\cos\alpha\,d\alpha.$$

This integrated over the limits $1\ \alpha=0$ and $\alpha=\frac{\pi}{2}$ gives the total attractive force due to the surface A B . . . $2\pi\sigma$.

In fixing $\alpha=0$ as one of the limits of the integral, we make the assumption that δ is very small in comparison with the extent of the polar surface. If another such surface were placed opposite the first, as indicated by the dotted line A′ B′, so that the point a lies between the two poles, and if A′ B′ were charged with an equal amount of magnetic matter of opposite sign to that distributed over A B, it would repel the unit pole with a force $2\pi\sigma$, which, added to the force of attraction, gives

$$4\pi\sigma$$

as the total force with which a unit pole would be urged across the air space. There must therefore be $4\pi\sigma$ lines of force to every square centimetre of the field. If the distance d between the two poles is very small, this is approximately the density of lines over the whole surface, and we find the total number of lines between the poles $Z=4\sigma\pi S$, the same expression as that found above.

If, instead of having only one air space d, we had two, each $\frac{d}{2}$ centimetres wide, nothing would require to be altered in our formulæ. Referring again to Fig. 16, imagine the polar faces to be cylindrical cavities as indicated by dotted lines and a cylindrical armature to be placed between, having a clearance of $\frac{d}{2}$, the intensity of the field will be

$$I=\frac{4\pi nC}{2\,\frac{d}{2}},$$

or, if we write $\delta=\frac{d}{2}$ for the air space and P for ampere turns of exciting power we have

$$I=\frac{4\pi P\,10^{-1}}{2\delta}.$$

This is the average intensity of field taken along the neutral diameter of the armature, not around its circumference. As a matter of fact, the first and last face of our system of magnetic shells are no longer parallel planes, but cylindrical surfaces. It has, however, been pointed out in the beginning of this article that it is only the contour of the shell and not the nature of its end face which need be considered, and hence our formulæ are equally applicable to the case of shells with cylindrical faces. Let b and d be the length and diameter of armature in an ideal dynamo with perfect field magnets, then the total number of lines of force passing across the armature would evidently be $I\,b\,d=Z$.

$$Z=\frac{4\pi P\,10^{-1}}{2\delta}.\,b\,d,$$

which might also be written in the form

$$Z=\frac{4\pi P\,10^{-1}}{\left(\frac{2\delta}{b\,d}\right)}$$

If we consider the fraction $\frac{2\delta}{b\,d}$ to represent a resistance, we have here Ohm's law translated into the magnetic circuit. According to this we have the following relation for a perfect electro magnet. *The total number of lines in a magnetic circuit is proportional to the ratio of exciting power and magnetic resistance.* In reality our magnets are not perfect, and hence the law is only approximately true; but for practical purposes the approximation is sufficiently near to enable us to use the above equation with some modifications for the designing of dynamos. If we have to do with a perfect magnet $\frac{2\delta}{b\,d}$ is the only resistance in the circuit. It is of the character, length divided by area, the same as the electical resistance of a conductor.

Since the field magnets and the armature offer also a certain resistance to the lines of force, we have to take it into account as well as the resistance of the air space. The equation for the number of lines crossing the armature must therefore be modified to

$$Z=\frac{P}{R_F+R_A+R\alpha},$$

where R_F represents magnetic resistance of field magnets.
R_A „ „ „ „ „ armature
$R\alpha$ „ „ „ „ „ air space

P being, as before, the exciting power in ampere turns. Suitable coefficients must here be introduced in the expressions for the three resistances to obtain the number of lines in such a measure that the product $Z\,N\,t\,n$ gives the electromotive force in the armature in volts.

(To be continued.)

BRAUER'S DYNAMO-METRIC BRAKE.*

BY H. WALTHER-MEUNIER.

Two striking charisteristics distinguish this brake, the invention of Mr. Brauer, from others of the same class. Firstly, it does not require when in action that its frictional surfaces should be constantly wetted; with ordinary wooden brakes this is absolutely necessary. Secondly, once the clutching action is established the brake regulates itself automatically, and further, there is not required, as with the ordinary brake, a long and cumbersome lever. An analogous arrangement to that of Mr. Brauer has been suggested by Mr. Kratz in his essay upon the dynamometric brake.† In the Brauer apparatus, instead of wooden jaws hugging the rims of the pulley, an iron band is used for flat-rim pulleys, and wire-ropes for grooved pulleys. The apparatus is composed of the following assemblage of parts:—

1st. The iron band or wire rope. 2nd. The clutch producing arrangement and the regulation of the tension of the clutch-producing bands or ropes.

The clutch or pressure of the bands or ropes upon the surface of the rim of the pulleys produces a friction corresponding to the effective work of the motor. The moment of this friction multiplied by 2π gives the work produced per revolution. To calculate this it only needs to determine an equal moment given by the additional charge or weight p, augmented by the weight of the regulating organs, the two weights affixed to the axis of the pulley, and p the moment required to maintain the system in equilibrium. The iron band applied to an ordinary flat-rim pulley is provided with four double guides k (Fig. 1), to retain the band in position, which is fixed up from the underside by means of a stirrup bolt and link and a safety cord l^1 l^2, in such a way as to allow the band to have a play of 100 milimetres. These safety measures can be modified according to local circumstances, and when the under part of the pulley or drum is inaccessible.

The clutching or frictional parts are actuated in the following manner:—The wire band is attached at its two ends in one instance to the point of the application of resistance a, and

* Translated and abstracted by B. H. Thwaite, A.M.I.C.E., in the *Proceedings* of the Institution of Civil Engineers. The original article appeared in the *Bulletin de la Société Industrielle de Mulhouse*, 1884.

† "Memoire sur les conditions à remplir dans l'emploi du frein dynamométrique," par M. Kratz, ingénieur en chef, inspecteur des manufactures de l'Etat Paris, 1873.

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in the other to the point of rotation b by a lever $a\ b\ c$. The point c of this lever is attached at d by means of a winding tackle $e\ e_2$, and a spring f, to the upper end of the wire band. The cord of the winding tackle after leaving e is passed round the friction-roller g. The operator by slightly pulling the cord will be able to produce the tightening or clutching action in such a way that the weight p is lifted up and equilibrium established. In order that this condition may not be influenced by the tension of the part of the cord from e_2 to g, it is only necessary to fix the friction-roller in such a way as to be in line with the axis of the pulley or drum. The moment of this tension will then be *nil*. The friction-roller is not absolutely indispensable, but its application permits the operator to control and watch the action of the dynamometric brake at some distance from it. The automatic regulation is effected, according to the variations of the friction, by the combined action of the coil-spring f and the cord h. It will be seen that if, owing to the band producing excessive friction, the weight p is lifted above its mean position, the cord h will be stretched, augmenting the tension, and consequently elongating the coil-spring f. The result is a diminution of the clutching action of the band, and the weight p will be lowered. The weight l, which replaces the necessity of attaching the cord h to the floor-boards, should be sufficiently heavy to equal the strain liable to be brought upon the cord h. The lifting tackle should always be suspended in such a way as to reduce the traction upon the cord h to a minimum, and so that the influence of this factor upon the condition of equilibrium in general need not be taken into consideration.

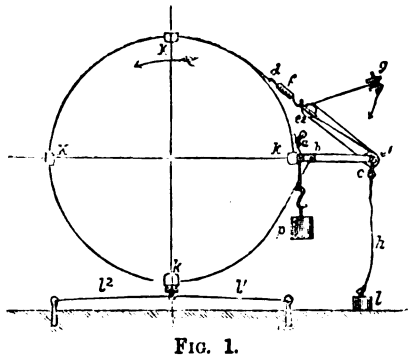

Fig. 1.

The effective work performed can be ascertained by the following formulas :—

$$T = \frac{(P+p)\,L\,\pi}{716{\cdot}2} \text{ horse-power (French).}$$

In which T = the effective work in horse-power;
P = the load-weight in kilos.;
p = the weight in kilos. of the regulating organs suspended to the point of attachment P;
L = the distance from the centre of the pulley to the point of attachment of the weight in metres;
π = the number of revolutions per minute.

Lubrication is effected by means of oil lubricators placed at the position marked a (Fig. 1). It is useless to try to cool the frictional surfaces by the use of water. If the pulley-rim presents to the surrounding air a surface equal to 10 square decimetres per horse-power, then the rim may be allowed to attain a temperature of as much as 100° Centigrade (212° Fahrenheit) without inconvenience. These conditions are generally realised by the flat rim or band pulleys, and by grooved pulleys, in each groove of which there is provided a wire rope of from 7 to 8 millimetres in diameter. For brakes of small dimensions the tackle arrangement can be advantageously replaced by means of a tightening screw. In the case of a vertical shaft the weight may be attached to a bent lever, or to a chain passing over a friction-roller. The use of the tackling arrangement is only very rarely required, seeing that the condition of equilibrium is maintained with great uniformity. Care must, however, be taken to attach the cord very firmly so that in case of need the tightening or clutching action can be instantly diminished or increased.

The following is a description of the dynamometric brake employed by Mr. Walther-Meunier to test the Brauer principle :—The application was made to a four-grooved pulley 2·15 metres (7ft.) in diameter, measured from the base of the grooves. The intention of the application was to measure the effective work performed by a 25 horse-power engine. The under portion of the pulley for a quarter of the π ran in a cemented race; it was therefore necessary to have recourse to a precautionary measure different from those already described. Figs. 2 to 8 show the arrangement devised by Mr. Brauer especially for this purpose. Each of the grooves was provided with a wire rope, A A, in two portions, one passing over the pulley, the other under. One of the ends of the upper portion was attached to the skate B (Fig. 3),

Fig. 2.

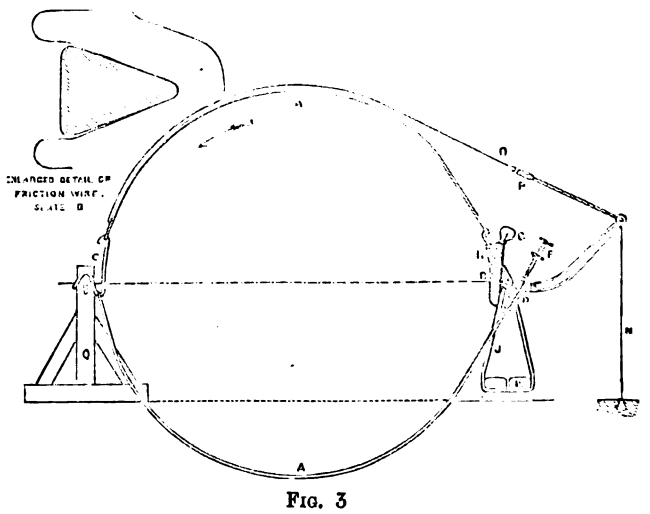

Fig. 3

a sketch of which, and enlarged, is shown (Fig. 2). The other end is attached to the double hook C (Fig. 3). The under wire rope is twisted round the hook C, and is attached at its other extremity to the rim of a stirrup D (Figs. 3 and 7), furnished with a boss, E, through which there works a tightening screw, F, provided with an actuating handle or wheel. The iron skate B (Fig. 3) is perforated obliquely to receive the lubricating medium from a needle lubricator, G. One end of the bent bar H is firmly let into the skate B; the apex of this bent bar H is twisted so as to carry the suspension bar I, firmly held in position by two nuts at its two ends.

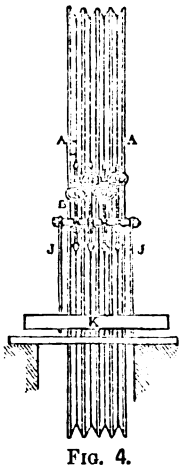

Fig. 4.

This suspension bar carries the stirrups J (Fig. 8), upon which rest the plates K for receiving the weights. The suspension bar also carries the bent lever L. This lever is provided with a bolt, M, upon which the pressure of the tightening screw F (Fig. 3) is exerted. The other end of the bent lever L is attached by a wire cord, N, to the floor, and also to the regulating apparatus, by means of a thin steel band, O, attached to the hook C, which through the coil-spring P is in direct communication with L. The complete arrangement of the brake is composed of four systems, similar to that already described, one for each groove of the pulley.

The brake being in perfect equilibrium, the centre of the highest end of the lever L was about 1 metre (3ft. 3in.) above

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the ground, and the cords N were arranged so as to be neither too slack nor too tight, but all about the same tension. In order to indicate the perfection of equilibrium, Mr. Brauer alternately relaxes and extends these cords. In this way the slightest variable resistances impossible of avoidance are compensated for in a sufficient manner. In the event of the breakage of one of the parts, the hook C is caught on the cross-piece of the framework support Q. The coil-springs P, owing to their attachment to the long bar of the lever L are never subjected to a greater strain than 10 kilograms (22lb.). In order to put the brake in action the suspension-bar should be placed exactly at the height of the centre of the axis of the pulley, and in the instance of the application above described the centre of the eye of the highest end of the lever L is about one metre above the ground. The cords N

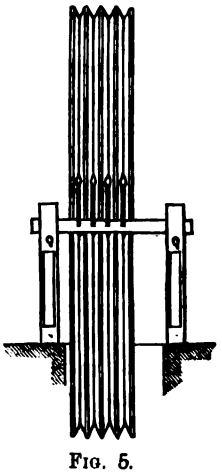

Fig. 5.

and the highest screw-attachments P should then be fixed. Before applying the brake it should be ascertained whether the pulley turns in the direction shown by the arrow (Fig. 3) without dragging the brake. The lubricators should now be examined, and a little oil should be poured into the grooves of the pulley. After weights are placed on the weight-suspender the tightening screw should be very gently turned until it lifts the weights from the platform, and leaves them in gentle oscillation near the condition of equilibrium. If the tightening screw is applied too violently, the cords will be extended without lifting the weight.

The following is a summary of the observations made by Mr. Burghardt, who has carefully tested Brauer's dynamometric brakes. Needle lubricators do not sufficiently lubricate the apparatus ; tallow is preferable as the lubricating medium. The brake worked well during the time the temperature of the pulley rim did not exceed 35° to 40° centigrade, and even up to 80° centigrade the action was still satisfactory, but the

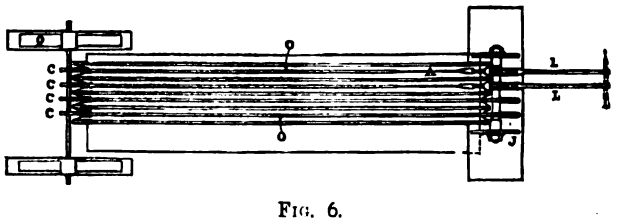

Fig. 6.

lubricating medium became too fluid, and was thrown off the grooves by the centrifugal force due to the speed of the pulley. The Brauer brake worked well for two hours with a load corresponding to 25 horse-power :—

1. The necessity of continually cooling the pulley rim by subjecting it to a stream of water, which is a great drawback to the use of ordinary brakes, is in the Brauer brake avoided.

2. The brake is not so cumbersome, and can be applied to motors *in situ* and in confined spaces.

3. The oscillations are very limited, and consequently the observations are more exact than with the ordinary brake, and the diagrams obtained by the indicator are clean and clear, and easy to calculate.

On the other hand, the Brauer brake is relatively rather more costly than those of the ordinary class, and it requires in its application a little more care than those of the ordinary and unscientific class. The excellence of the Brauer brake is such that Messrs. Walther-Meunier and Burghardt decided to utilise it in their investigations of the following important questions :—1st. Whether it is advisable to work a steam engine with or without condensation. 2nd. Whether it is advisable to work with low pressure and low expansion, or with high pressure and high expansion. 3rd. What is the variation of the effective work under different loads.

The motor used in order to investigate these questions was on the Collman system, having four distributing valves, two for inlets and two for exhaust, the former having variable expansion gear. The engine was also provided with a condenser. The mechanical parts of the engine were perfectly

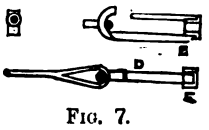

Fig. 7.

balanced. The engine had a piston stroke of 600 millimetres (about 24 inches.) Its piston was 301 millimetres (12 inches) in diameter. The engine was worked at 70 revolutions per minute. The net weight of the brake was established as suggested by Mr. Brauer, neglecting the weight of the iron bands or wire ropes, coiled springs, &c. The following details enter into this account :—

Distance from the centre of the pulley axis to the point of attachment of the weights	1·185	metre.
Weight of the four cast iron skates ...	31·50	kilos.
„ „ lubricators.....	0·90	„
„ load carriers or suspenders	10·20	„
„ attachment levers	39·25	„
Total	81·85	„ (180lbs.)
Deduct the weight of the four safety hooks	6·50	„
Net weight of the brake =	75·35	„ (166lbs.)

Corresponding at 70 revolutions to the work, equivalent to 8·727 horse-power, or

$$T = \frac{1}{716{\cdot}2} \times 75{\cdot}35 \times 70 \times 1{\cdot}185 = 8{\cdot}727 \text{ h.p.}$$

The number of revolutions per minute was registered by a counter connected to the main shaft. Twenty diagrams were taken at each end of the cylinder, all those indicating any irregularity in the working of the brakes being eliminated.

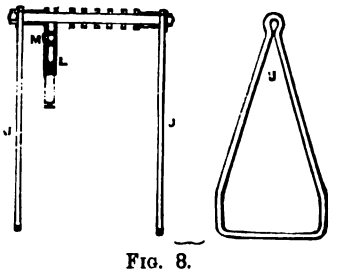

Fig. 8.

The following is a summary of the conclusions arrived at by Messrs. Walther-Meunier and Burghardt :—1st. It is desirable to work a steam engine with a load proportionate to its dimensions. 2nd. It is desirable to employ condensation where local circumstances will permit, even for engines of comparatively small dimensions, on the condition that the condenser and its actuating mechanism are carefully and intelligently proportioned. 3rd. It is desirable, even with single-cylinder engines, to work with the highest pressure. 4th. It is highly desirable that every possible precaution should be taken to ensure a perfect and continuous lubrication of the frictional parts of all steam-engines without exception. The serious study of lubricating methods and lubricants deserves the attention of all steam-users.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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VOLUME XIV.

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THE POSTMASTER-GENERAL'S REPORT.

The Report of the Postmaster-General for the year ended 31st March, 1885, is, as usual, both satisfactory and interesting so far as the Post Office is concerned; but in respect to the Telegraph branch of the public service there is little that is gratifying and still less encouraging to be found in the Report. Such, at least, is the view one may naturally take of it at this present juncture. Mr. Shaw-Lefevre says "the telegraph business of the country shows but little development;" and in proof of it he cites the fact that there has been only an increase of 435,000 messages during the past year. Under a tariff reduced by fully one half there will doubtless be a huge "development" in the sense of an increased number of messages; but probably also a not less marked development on the wrong side of the revenue account. The steadily diminishing increase of telegrams which has taken place during the past five years is attributed to "stagnation of trade, the competition of the telephones, and the rapidity of the letter post." As there are no signs of improvement to the telegraph's advantage in these respects the time is not happily chosen for an experiment which will add immensely to the capital account whilst greatly lessening the ability to pay interest upon it.

The ruling powers have convinced themselves, however, that an augmented increase in the number of telegrams is not only desirable of itself, but that anything short of it "cannot be regarded as satisfactory." We ourselves should be rather disposed to say that the annual increase had reached its maximum, and that no considerable development in that direction can or ought to be expected. The Telegraphs have now been worked by the State for fourteen years. During the first three or four years the annual increase was at the rate of two to three million messages; but since then, except in the year 1880-81—a year of exceptional prosperity—the increase has been steadily falling. And this is not to be wondered at. No business can hope to go on for ever increasing at the same rate; if it keeps pace with the progress and population of the country this is as much as we have any right to expect. That there has been an enormous development in the telegraph business under Post Office administration is unquestionable. Commencing with a total of barely ten million messages in 1870-71 it had doubled that number in five years, and trebled it in the year 1880-81. From that year the increase has slackened, as was to be expected, and proceeds now at something like half a million a year, the total number of messages for the past twelve months being 33,278,459. Notwithstanding a very considerable addition to the number of telegraph offices open, and to the increased facilities afforded to the public for the transmission of their messages the increase of traffic is diminishing; and we can only infer from all this that the telegraph business of the country has reached its normal limit or thereabouts, and that nothing but an artificial stimulus will provoke any material enlargement.

Whether the stimulus of a sixpenny rate will add to the financial prosperity of the service is a very doubtful matter indeed. The late Postmaster-General points out, and indeed almost makes it a matter of complaint, that the revenue has not contributed anything for two years past to the interest on the capital invested. This, however, is accounted for by the outlay in anticipation of the increase of traffic under the reduced tariff, the expenditure last year alone exceeding the revenue by about £36,000. But in a few years' time this expenditure must have been required to meet the ordinary increase of business under the existing tariff; and we cannot agree with many writers on this subject who allege that all this money will be wasted should the sixpenny telegram scheme fall through. What is really to be apprehended is that sixpenny telegrams will contribute less to the payment of interest on capital than shilling telegrams do at present. It is gratifying, however, to notice a confirmation of our oft-repeated opinions in the action of the new Postmaster-General. Three words for sixpence with free addresses may be thought by some people preferable to twelve words addresses included. We have no objection to offer if the public are anxious to take their ha'porth of beer out of a quart pot in the fashion suggested by Lord John Manners; but we regard it as a full and unqualified confession that the free addresses are a financial mistake, and that in some way or other they must be either abolished or paid for in a disguised form.

As to the effect on the Telegraph revenue of the development of private Telephone business, we can hardly doubt it; yet it is remarkable that the figures do not betray this influence in the locality where we should expect to find it. Local London telegrams appear to increase in the same ratio as provincial telegrams, and we cannot perceive any marked falling off in the former during

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the past three years, when metropolitan telephony has been so greatly extended. But accepting the Postmaster-General's opinion on this point, it is plain that the Department does not reap any large compensation for its losses on account of the rival Telephone Companies. The total royalties paid by them amounted to only £19,370 last year—a sum which at once disposes of the outcry against the extortion of the Post Office, and of the excuse on this account put forward by the companies to justify their high charges. Neither have they much cause for complaint on the score of Post Office competition. Twenty-seven Telephone Exchanges in various country towns, with a total list of 1,141 subscribers, represent the amount of departmental activity in this direction, and the total receipts do not much exceed the trifling royalty on their business contributed by private companies. "The full effect of the Telephonic competition," says the late Postmaster-General, "remains to be seen, but I cannot doubt that the Telegraph Revenue has been and will be adversely affected." If this be so it is a matter for regret that we find no indication of a policy designed to check the adverse effects of that competition. Sooner or later this will have to be done; and it is perfectly evident that reducing the rates for ordinary telegrams will not do it.

We are glad to notice that attention has been drawn in this Report to the advantage the nation derives from its connection with the Telegraphs in the help it affords to military expeditions which are now of almost periodical occurrence. On several former occasions the employment of Royal Engineers in the Postal Telegraph Service has enabled the military authorities to despatch a body of trained and experienced soldiers to the seat of war who otherwise would have been hard to find and far less efficient. No fewer than six officers, and one hundred and six men have been so detached for active service in Egypt and Bechuanaland within the past year. To this number must be added about thirty of the Reserve Telegraphists belonging to the permanent staff of the Post Office, most if not all of whom are still performing arduous and honourable service for their country either in Upper Egypt or at Suakim.

CORRESPONDENCE.

SIXPENNY TELEGRAMS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If you would allow me to somewhat disagree with your expressions on sixpenny telegrams, I should like to state that I entirely fail to see any difficulty in harmonising Mr. Lefevre's and Lord John Manners' schemes relating to this matter. The plan of tariff that seems to me a very fair and business-like compromise I will shortly detail. Let the sixpenny telegram consist of a message of six words, the address of recipient, and three words to indicate the sender, being free; and let additions made to the sender's address and the message be charged at the rate of two words for a penny. The advantages would be these: a shilling telegram would contain almost as much as one now sent at a similar charge; the address of recipient and the message would not often exceed Mr. Lefevre's maximum number of words; the difficulty of shortening necessarily intricate addresses would be avoided; the Bill's passing would be assured, and a boon conferred on the whole of the country. This tariff, too, would be as remunerative as Mr. Lefevre's, while six words for sixpence and a penny charge for every additional two would give a definite meaning to a sixpenny telegram. Of course, a message of six words is short, but it was to facilitate the sending of such a message that the Bill was originally introduced.—Yours, &c.,

CECIL J. BLACKER.

121, St. George's-road, S.W.

LOCALISING A PARTIAL EARTH FAULT IN A CABLE WHEN A RETURN WIRE IS NOT OBTAINABLE.

TO THE EDITOR OF THE ELECTRICIAN.

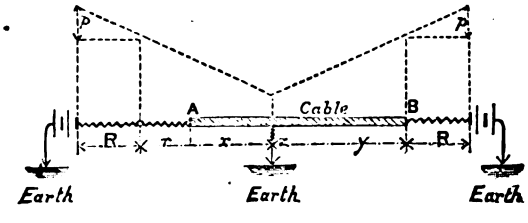
SIR: I have read with great interest and pleasure Messrs. Anderson and Kennelly's modification of Blavier's well-known test in your issue of 17th July.

Every electrician who has had to localise variable and high resistance faults in a single cable (where no loop or return wire was available) must have felt how inapplicable Blavier's method was, more especially if the fault was near his end of the line.

"Fall of potential" tests no doubt yield excellent results when carefully applied; but the necessary apparatus and skill are not always at hand. I believe, therefore, that Messrs. Anderson and Kennelly's test will be often preferred, and they certainly deserve thanks from all whose duty it is to localise faults in submarine cables, by having not only devised the test, but in having so fully and clearly demonstrated its limits of sensitiveness.

It has occurred to me that instead of applying the "fall of potential" test at one end of a cable at one time only, it might be found practicable in certain cases to apply the test simultaneously from each end in the following manner:—

Join up batteries of *precisely* the same E.M.F. with *equal* resistances R and R in circuit with the cable A B. Introduce a resistance, r, at the end A nearest the fault, until the difference of potential p and p obtained between the ends of the resistances R and R becomes precisely the same, taking care to



eliminate or allow for any natural cable current by balancing the same with a compensating battery placed between R and r or R and the B end of cable, as the case may require.

Then the distance from A to the partial earth fault at z will be $x = \frac{l-r}{2}$ ohms, where $l = n + y$ ohms the total copper resistance of the cable.—Yours, &c., ANDREW JAMIESON.

College of Science and Arts, Glasgow, July 18, 1855.

INVENTIONS EXHIBITION GRIEVANCES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having read the letter from Mr. Henry F. Joel in your paper, I am extremely glad to see that someone has taken the matter up, as I certainly consider that there is room for very considerable improvement. My own experience is this. It is now nearly three months since the Exhibition was opened, and still some portions of the Eastern Arcade are very badly lighted. The authorities have now made three attempts at the lighting. Firstly they had oil lamps, secondly arc lamps which they moved since, and now they have some crystal lamps, and even yet these are not permanently lighted. Now that the Exhibition has been opened half its term it is almost time something was done.

I also think that the pass business is a very great inconvenience and troubles a great many.—Yours, &c.,

July 22nd, 1885. AN EXHIBITOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the letter of your correspondent, H. B. Joel, in last week's issue, the difficulty about personal tickets being used by others than their rightful possessor would be met by their being pasted on the back of a *carte de visite*, as was done at the Paris Exhibition of 1878, the Brussels Exhibition of 1880, and is the rule at the present Antwerp Exhibition.—Yours, &c., J. W. P.

Brussels, 22nd July, 1885.

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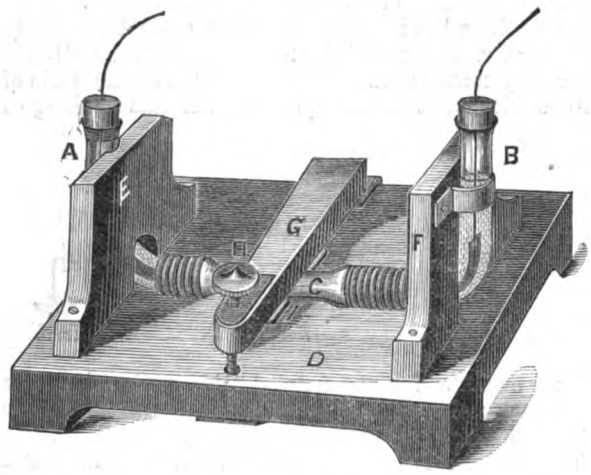
A SIMPLE FORM OF VOLTAIC-REGULATOR*.

BY DR. G. GORE, F.R.S.

Having used the following apparatus with satisfactory results in a very large number of experiments, in which comparatively feeble voltaic currents varying from about one-fiftieth to one-thousandth of an ampere were employed, I beg leave to describe it.

The construction and action of the instrument are indicated by the annexed sketch, but in order to adapt the apparatus to currents of the range of strength mentioned below, it is desirable to state the dimensions of some of its parts. A B are two glass tubes, about 2·0 cm. diameter, and 10·0 cm. high, bent at right angles. Their upper ends are about 20 cm., and their lower ones 8·0 cm. apart; and the latter are united by a vulcanised india-rubber tube of their own diameter. The tubes are nearly filled with a three-fourths saturated solution of non-acidified cupric sulphate, in which are wholly immersed two electrodes of sheet copper, 8·0 cm. long and 1·5 cm. wide, the lower ends of which project some distance within the india-rubber tube. The tubes are supported by the base-board D and the two wooden uprights, E F. By means of the



wooden lever G, which is about 2·5 cm. wide, and has a hinge at one end and a thumb-screw, H, at the other, the middle part of the vulcanised tube, resting upon a small block of wood, I, may be very gradually and strongly compressed.

With tubes and electrodes of the dimensions given, any strength of current, ranging from ·0001 to ·05 ampere, may pass without interference of polarisation; and, with a steady lever, a screw of slow motion, and the india-rubber tube slightly stretched, the current can easily be regulated to a 1-100,000th of an ampere.

ON THE "GROUPING SYSTEM" FOR THE DISTRIBUTION OF ELECTRICITY.†

BY W. H. SNELL, A.S.T.E. AND E.

The method of distributing electricity at approximately uniform potential, which has been termed the "Grouping System," may be briefly described as follows:—

The whole area to be supplied is divided into districts, in each of which there should be an approximately equal consumption of electric energy. The mains supplying these districts are connected with one another in series—that is to say, the negative main of the first district is joined to the positive of the second, and so on. Within the limits of each district the distribution is effected by means of a parallel system of branch mains, either double or multiple. In order that the current from the dynamo may *without waste* be equalised throughout the system (notwithstanding the continuous variation in the demand) a "compensating room" is established in each district. The compensation is effected by means of secondary batteries which are connected in parallel with the lamps, and are to be capable of maintaining the required difference of potential and of supplying the requisite number of ampere-hours of current *per diem*.

The advantages of such a system may be summarised as follows:—

(1.) Economy of metal in the mains.
(2.) De-centralisation of engine station.
(3.) Comparative immunity from breakdown.
(4.) Increased life of lamps.
(5.) Probable economy of working expenses.

Most of these points are too obvious to need any explanation. With regard to the second, it will be clear that the engines may equally well be placed in any one of the districts. The last claim refers mainly to the fact that the machines may cease running at night, the current being still available from the batteries; but there will of course be something to set upon the other side of the account for maintenance of the cells.

Before we proceed to discuss the conditions of working there are two or three points which it may be as well to note in this place. It is obviously desirable that while the machines are running the work should as far as possible be performed by them, rather than by the cells. It will be shown hereafter that by a proper adjustment of the E.M.F. of the dynamos the total work of the cells may be permanently maintained at (or very nearly at) its minimum *possible* rate under any given distribution of lamps. It is not essential that a compensating room should be placed in any particular part of its district. It is, however, desirable that it should be at, or near to one end rather in the centre — *which* end is indifferent, except in certain special cases. By placing the rooms at the junctions of the districts we may have two sets of batteries in each, and thus only half as many rooms will be required. On the other hand, by placing the cells in the centre of a district the "economical length" of the district is doubled. Again, in any one or more districts we may place more than one set of cells, and join them up in series, in order that we may make use of the "multiple main system" within the limits of these districts. This plan is principally of service where the number of lamps which have to be fed from branches is large compared with the number which can be supplied directly from the main. It is of course understood that branches may be taken off from any part of the main (no matter where the battery is placed), so that as far as the dynamo is concerned the distribution is *from a line of constant potential*, instead of being from a point, as in other systems. It will thus be apparent that the system is very flexible, and it is probable that it can readily be adapted to any conditions likely to occur in practice.

The following are some of the questions that will have to be considered before the system can be practically applied:—

(1.) To determine into how many districts the area to be supplied should be divided.

(2.) To adjust the "economical length" of the system with its measured length under the given conditions.

(3.) To determine what (if any) adjustment should be made in the E.M.F. of the machine so as to maintain the work of the batteries at a minimum.

(4.) To provide for a proper control of the charge and discharge of the batteries from the engine station.

(5.) To arrange for a continuous supply of current. The difficulty here is to keep the potential in the mains at its proper value during the time that the cells are being charged.

No doubt there are other problems which will present themselves for examination, but in the meantime we will deal with those here enumerated *seriatim*.

We have, then, first to determine into how many districts the area to be supplied shall be divided. For this purpose, we may make use of the equation

$$E_x = N E_y + C R, \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where N is the number of districts, E_y is the maximum E.M.F.

---

* Read before the Birmingham Philosophical Society, June 11, 1885.

† This method was first described in a patent obtained by Rear-Admiral Arthur in May, 1882. In the year 1884 Mr. Preece (without being aware of the existence of such patent) employed accumulators in this way in his experiments on street lighting at Wimbledon. This, I believe, is the first and only instance in which the method has been put into practice.

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of each battery *during charge*, C is the maximum charging current, and R is the (estimated) resistance of the external circuit of the dynamo during charging. E_x is therefore the maximum E M.F. which will be required at the terminals of the dynamo. But this E.M.F. must not be permitted to exceed the limit of safety and of economical insulation. *Then we may make N as large as possible consistent with these conditions.* It will, however, be better to take N somewhat below its highest permissible value, because we can then undertake to charge any cells belonging to private consumers, besides allowing for future extension. In reckoning the value of N in equation (1) it is to be noted that any district served by n mains will for this purpose count as $(n-1)$ districts, inasmuch as the fall of potential is, in such a case, equivalent to that in $(n-1)$ districts supplied by *two* mains only.

Having thus determined the number of districts, the next point is to compare the "*economical length*" of the system with its actual linear measurement taken along the course of the main from the + to the − terminal of the dynamo. Let the actual length of the system when so measured be called L. Let λ be the economical limit for the distance between any battery and the farthest lamp in its district; and let L_1 be the economical length of the whole system. Then we must arrange so that L_1 shall not be less than L. But for L_1 we have

$$L_1 = N \lambda \alpha \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where (assuming for the present that multiple mains are not employed) the factor α depends upon the position of the compensators in their several districts. If every compensator is situated at one end (either + or − end) of its district, then α is obviously equal to unity. But if the batteries are placed each in the centres of their districts, α will become equal to 2, which is its maximum value under the given condition. When the cells are all in some (the same) intermediate position α obtains a proportionate intermediate value. When, in the more usual case, the relative position of the cells differs from district to district, we must put

$$\alpha = \frac{\alpha_1 + \alpha_2 + \ . \ . \ . \ \alpha_N}{N} \quad . \quad . \quad . \quad . \quad (3)$$

But when multiple mains are introduced the values of α_1, α_2, &c., will depend upon the number and also upon the relative size of the intermediate mains. I have dealt with this point at length in a paper which appeared in *The Electrician* (Vol. XIV., p. 412). The values of α_1 α_2 . . . found as before must be multiplied by the value of expression (5) (of that paper). Within the limits of practice this multiplier will lie between (about) 1·6 to (about) 2·6. It will be observed that in (2) N represents the actual number of districts, and not the number reckoned as in (1).

We have next to find the economical length of each district; this we have already called λ. Let the resistance of a part of the main of length λ be put equal to r_2, then the value of r_2 must be such that when the dynamo is not at work the difference of potential at the terminals of a lamp at distance λ from the battery (along the main) shall not be less than the required percentage of the maximum potential which is permitted.

Let this percentage be expressed by the fraction q.
" E_2 be the E.M.F. of the battery during discharge.
" ρ " " resistance of the battery.
" l " " " of one lamp.
" μ " " maximum number of lamps which in practice one battery will be required to supply for any length of time.

Then we must have the following relation

$$q E_2 \frac{1}{\frac{l}{\mu} + \rho} = E_2 \frac{1}{2r_2 + \frac{l}{\mu} + \rho} \quad . \quad . \quad . \quad . \quad (4)$$

But also let M be the total number of lamps in the system, and put

$$\mu = \frac{p M}{N},$$

where p is some fraction for which we can readily estimate a value. And ρ will be some known function of the number of amperes which the battery can deliver, and can therefore be expressed as a function of μ.

Let us put $$\rho = \frac{s}{\mu} = \frac{s N}{p M}.$$

Making these substitutions in (4), and transposing, we shall get

$$r_2 = \frac{N (l+s) (1-q)}{2 M q p} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

It appears, however, that s will always be negligible in this position.

Next let r_3 be the *economical resistance per unit length of the main* under the given conditions. If this unit length be written λ_1, we shall have for the value of λ

$$\lambda = \lambda_1 \frac{r_2}{r_3} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

The value of r_3 will be determined from calculations of "the mean annual thermal current." * Now, if C_θ be the mean value of this thermal current per district, we may conveniently put Sir W. Thomson's "equation of economy" into the form

$$W = C_\theta \sqrt{b \rho_1} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

where W is the weight of the conductor in pounds per unit of length, ρ_1 is the resistance of a conductor of unit length weighing one pound, and b is a term depending only upon the financial data.† Now, if for W we put $\frac{k}{r_3}$, k being a known constant, we shall obtain from (7)

$$r_3 = \frac{k}{C_\theta} \sqrt{\frac{1}{b \rho_1}} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Now, in (6) substitute this value of r_3, and also substitute for r_2 from (5); we then get for λ

$$\lambda = N \lambda_1 C_\theta \left\{ \frac{(l+s)(1-q)}{M q p k} \right\} \sqrt{b \rho_1} \quad . \quad . \quad (9)$$

All the terms in this expression are known with more or less accuracy. Finally, substituting this value of λ in (2), we obtain L_1, the economical length of the system. It should be observed that, although the above expression for λ contains the term N in the numerator, yet inasmuch as C_θ will vary almost exactly inversely with N, the value of λ is really very nearly independent of N.

Now if L (the total economical length) is less than L_1 (the real or required length), we may either attempt in some way to increase the value of expression (9), or we may make some alteration which will increase the value of α in (2), or else we must consent to depart from the economic value of r_3 in (8). Or, finally, we may possibly find it desirable to increase the number of districts.

Consider next what should be the E.M.F. at the terminals of the dynamo in order that the total work done in or by the batteries may be maintained at a minimum value, while the dynamo is running. We also require an expression for the current through the lamps, let E_1 be the required difference of potential at the terminals of the machine. And suppose, in the first instance, that we have the same number of lamps alight in every district, and let this number be n. Under these circumstances it is clear that E_1 should have such a value that no current shall flow through the batteries either in the positive or the negative direction. And we shall show that this condition is fulfilled when we maintain the value

$$E_1 = N E_2 \left(\frac{l + n r_2 \alpha}{l + n r_2} \right) \quad . \quad . \quad . \quad . \quad (10)$$

Now, in this expression if α be unity (a value which we have already seen it never much exceeds) then the term within the brackets is also equal to unity, and we have simply

$$E_1 = N E_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

But this last expression does not contain n, therefore in this

* For an explanation of this term, and the method of calculating it, see a paper read before the Society of Telegraph-Engineers and Electricians, June 11th, 1885, "On the Calculation of Mains for the Distribution of Electricity."

† This is taken from the paper already alluded to.

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case the current through the cells will still be zero whenever the number of lamps alight is the same in each district, whatever that number may be.

But again, whatever may be the value of α (within the known limits), inasmuch as r_2 is very small indeed compared with l, it will be seen that the expression for E_1 in (10) varies very little with different values of n, so that in any case we make E_1 constant at a point determined by selecting a mean value of n. But further, it will readily be seen that although in practice this condition (that the number of lamps in use is equally distributed) is not actually attained, yet the same value of E_1 must maintain the work of the batteries (positive or negative) at a minimum, whatever may be the actual distribution at any given time. When the distribution is not equable, then the work being done in or by the cells is least in those districts where the value of n is nearest to its mean value throughout the system at that particular moment. It does not seem possible to obtain any perfectly general solution of the distribution of work, but special cases may often be treated by the aid of the equations we are about to develop.

We have now to show how equation (10) has been determined. It is well known that in any network of conductors containing various sources of E.M.F., if there is any branch in which the current is zero that branch may be removed, together with whatever source of E.M.F. it may contain, without causing any alteration in the distribution of current in the remaining branches. If, therefore, we establish the condition of an equal distribution of lamps and such a value of E_1 as will make the currents through the batteries equal to zero, we may then select one district and find expressions for the current in the lamps and cells in this district under the assumption that throughout the remainder of the system the batteries have been disconnected, and these expressions will hold good for this district when the connections are re-established.

We may therefore reduce the system *pro tem* to the case indicated in Fig. 1. The lettering is taken to represent the resistances of the different parts of the circuit.

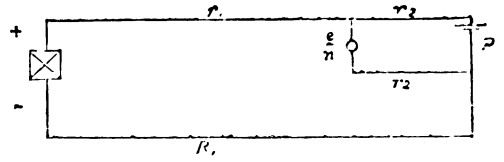

FIG. 1.

We will now put

$$r_1 + R_1 = r' \; ; \quad \rho + r_2 = r'' \; ; \quad \frac{l}{n} + r_2 = r \quad . \quad . \quad (12)$$

And if R be put for the total resistance of the mains from the + to the − terminal of the dynamo, we may write for r'

$$r' = (N-1)\frac{l}{n} + (R - r_2) \quad . \quad . \quad . \quad . \quad (13)$$

But it is clear that R stands in the same relation to r_2 as L_1 stands to λ; that is,

$$R = N r_2 \alpha \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

Making this substitution in (13), we have finally

$$r' = (N-1)\frac{l}{n} + r_2 (N\alpha - 1) \quad . \quad . \quad . \quad (15)$$

Next, let c_1' be the current in r' due to the dynamo, and let c_1'' be the current in r'' due to the battery.

These currents are in opposite directions, so that if c_1 be the resultant current in r'

$$c_1 = c_1' - c_1'' \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

Again, let c_2' be the current in r'' due to the dynamo, and let c_2'' be the current in r'' due to the battery.

These currents are also in opposite directions, so that if c_2 be the resultant current in r''

$$c_2 = c_2'' - c_2' \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

Finally, let c be the current in r then having regard to the sign of c_2, we shall have

$$c = c_1 + c_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

We proceed to express these currents in terms of E.M.F. and resistance. For the sake of brevity we will put

$$A = (r\,r' + r\,r'' + r'\,r'').$$

Then we shall obtain

$$c_1' = \frac{E_1 (r' + r'')}{A} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

$$c_1'' = \frac{E_2\, r}{A} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

$$\therefore \; c_1 = \frac{E_1 (r + r'') - E_2\, r}{A} \quad . \quad . \quad . \quad . \quad . \quad (21)$$

$$c_2' = \frac{E_1\, r}{A} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (22)$$

$$c_2'' = \frac{E_2 (r + r')}{A} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

$$\therefore \; c_2 = \frac{E_2 (r + r') - E_1\, r}{A} \quad . \quad . \quad . \quad . \quad (24)$$

and

$$c = \frac{E_1\, r'' + E_2\, r'}{A} \quad . \quad . \quad . \quad . \quad . \quad . \quad (25)$$

Now when c_2, the current in the battery, is equal to zero, we have from (24)

$$E_2 (r + r') - E_1\, r = 0 \quad . \quad . \quad . \quad . \quad (26)$$

Substituting for r' and r from (15) and (12), and transposing, we obtain for E_1, the value already quoted in (10),

$$E_1 = N E_2 \left(\frac{l + n r_2 \alpha}{l + n r_2} \right) \quad . \quad . \quad . \quad . \quad (10)$$

This expression has been discussed already.

Next, let c_0 be the current per lamp when n lamps are burning, so that $c_0 = \frac{c}{n}$.

Then, if for the time we regard r' and r'' as fixed resistances, by substituting in (25) we shall get

$$c_0 = \frac{E_1\, r'' + E_2\, r'}{(l + n r_2)(r' + r'') + n\, r'\, r''} \quad . \quad . \quad . \quad (27)$$

Now r'', and therefore also r_2, is always a very small quantity, therefore looking at (15) we see that r' varies very nearly inversely with n, so that n really vanishes from the last term of this denominator. And further, as l is extremely large compared with r_2, n is of very little importance in the first term. So that we may conclude that the current per lamp is sufficiently independent of the number of lamps alight in its own district, and it may be shown (although, perhaps, it will follow *à fortiori*) that it is also practically independent of the number of lamps in any or all of the remaining districts.

It is, however, more important to note the relative effect upon c_0 of any variation of E_1 or of E_2. If in (27) we substitute for r' and r'' from (15) and (11), we shall obtain

$$c_0 = \frac{n E_1 (\rho + r_2) + E_2 \{ l (N-1) + n r_2 (N\alpha - 1) \}}{n A} \quad . \quad (28)$$

from which we see that any small change in E_1 has an extremely small effect upon the current in the lamps, compared with that which would follow a similar change in E_2. It may be worth while to put down the complete expression for A; this may be written, with very close approximation,

$$A = \frac{1}{n^2} (l + 2 n r_2) \{ l (N-1) + N n (n r_2 + \rho) \} \quad . \quad (29)$$

Now, suppose that E_1 is maintained at the value $N E_2$, and let us also suppose that in one district the number of lamps burning changes from n to n_1, and let n_1 be greater than n. If we now take c_0 to indicate the *normal* current per lamp, the current traversing the whole number of lamps in this district may be considered to have increased by the quantity

$$(n_1 - n)\, c_0,$$

and the greater portion of this additional current will be supplied by the battery, as we shall presently show. But that some part of the extra current must come from the dynamo

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is obvious, because the change has caused a decrease in the resistance of the dynamo circuit. And this additional dynamo current will traverse the cells in the remaining (N – 1) districts in the negative direction, that is as a *charging* current.

Now change n to n_1 in a second district. There is now a somewhat smaller positive current delivered by *two* batteries, and an increased negative current in the (N – 2) batteries. And if n is charged to n_1 in the remaining districts successively, the negative current increases continually while traversing a decreasing number of batteries, and the positive current decreases continually while traversing an increasing number of batteries; so that when in all districts n has become n_1 the negative current has been eliminated, and the positive current is reduced to zero, and the batteries are again idle.

Following out this reasoning, we may conclude that when n varies indefinitely throughout the system the current in the batteries, whether + or –, will always be least in those districts where the number of lamps burning approximates most nearly to the average number alight per district, at the given time, whatever that average number may be.

From this we may also deduce as a corollary that the total work done in or by the batteries under any given distribution of lamps is least when E_1 has such a value as would make the battery currents zero if the lamps in use were equally distributed. But as we cannot write any general expression for r' it does not seem that any more formal proof can be given.

The following proposition is also, perhaps, worth recording. Let the number of lamps burning in (N – 1) districts be not very different from an average number, say n. In the remaining district let the number be n_1. Then the *extra* current will be equal to

$$\pm (n-1)\, c_0,$$

and this current will be divided between the battery and the dynamos in the (approximate) ratio

$$l(n-1) \;:\; \mathrm{N}\, n\, (2\, r_2 + \rho).$$

From this it will be seen how very slight is the effect of a disturbance in one district upon the current, either in the lamps or the batteries of any other.

(To be continued.)

PECULIAR CLASS of CHEMICO-ELECTRIC CURRENTS.*

BY DR. G. GORE, F.R.S.

In an ordinary voltaic cell chemical corrosion of one of the metals is an essential condition of production of current. In the present experiments I have endeavoured to obtain electric currents by means of chemical change in electrolytes without such corrosion, and without applying different temperatures to the two plates.

The plan adopted has been to obtain the current by means of a chemical alteration in the liquid alone:—To select a very easily decomposable electrolyte, or one in a state of unstable chemical equilibrium, either at or near the temperature at which it spontaneously changes, immerse in it two different metals, neither of which is corroded by the liquid, but which, in consequence of their static electric polarity produced by contact would be differently related to the chemical change, and thus determine the direction of the current produced by it; and, after immersing the metals, raise the temperature of them and of the liquid equally.

The mode of procedure was to immerse a pair of plates, one being of gold and the other of platinum, in the liquid; connect them with a galvanometer, note the amount of steady deflection at atmospheric temperature, and then gradually raise the temperature of the mass of liquid, until the chemical change occurred; and in cases where the liquid returned to its original chemical state on cooling, allow it then to gradually cool, and note the direction and amount of the deflection. The galvanometer employed was an astatic and differential one, the two coils of which, each having a resistance of 50 ohms, being connected as a single undivided circuit.

The liquids tried were:—1, peroxide of hydrogen, ten volumes, containing much chloride; 2, a rather strong solution of potassic chromate, acidified with sulphuric acid; 3, the same mixture, with some spirit of wine added to it; 4, a weak solution of permanganate of potassium; 5, the same, with some sulphuric acid added to it; 6, a weak solution of potassic iodide, mixed with dilute sulphuric acid; 7, the same, mixed with nitric acid; 8, a mixture of strong nitric acid and three times its bulk of water; 9, a mixture of wet, freshly precipitated green cupric hydrate, and solution of potassic sulphate containing free potassic hydrate; 10, a solution of chloride of cobalt containing some hydrochloric acid; 11, a solution of subchloride of copper in hydrochloric acid.

Experiment 1.—Hydric peroxide. Platinum was positive and gold negative at 50° F., deflection 1·0°; at 100° F. 5·0°; at 160° F. 8°, and at 200° F. 14°. By cooling to 110° F. the deflection was 0; and at 100° F. gold was positive 1·0°.

Experiment 2.—Potassic chromate acidified with sulphuric acid. Platinum positive at 58° F. 2·0°; at 140° and 180° F. 6·0°. It is probable that the increase of current in this case was due to decrease of resistance by rise of temperature.

Experiment 3.—The same solution, with alcohol added to it. Platinum positive at 58° F. 1·0°; at 90° F. 7·0°; at 120° F. 8·0°; at 160° F. 9·0°. The liquid was decomposing quickly at about 120° F.

Experiment 4.—Permanganate of potassium solution. Gold positive at 50° F. 1·0°; at 100° F. 3·0°; at 140° F. 0°; at 180° F. platinum positive 5·0°; and at 200° F. gold positive 2·0°.

Experiment 5.—The same solution, with sulphuric acid added. At 52° F., gold positive 2·0°; at 80° F. 4·0°; at 90° F. 0°; at 95° F. platinum positive 2·0°; at 150° F. 25·0°; and at 210° F., deflection 60° degrees. A thin film of manganic oxide formed on each metal.

Experiment 6.—Potassic iodide, mixed with dilute sulphuric acid. At 58° F., gold positive, and gradually and increasingly so up to 180° F., at which temperature the deflection was 70°. Gas appeared on both metals.

Experiment 7.—Potassic iodide, mixed with dilute nitric acid. At 58° F. gold positive 8·0°; at 90° F. 30·0°; at 110° F. 40·0°; at 125° F. 50·0°; and at 180° F. 60·0°. The liquid in this and the last experiment commenced to become brown at about 120° F.

Experiment 8.—Mixture of nitric acid and water. At 55° F. gold positive 5·0°; at 100° F. 40·0°; at 180° F. 35·0°; and at 200° F. 10·0°. On boiling the liquid, the current suddenly increased and became irregular.

Experiment 9.—The mixture of cupric hydrate with solution of potassic sulphate and hydrate. At 62° F. gold positive 2·0°; at 66° F. platinum positive 1·0°; at 80° F. gold positive 5·0°; and at 160° F. 4·5°. The hydrated oxide of copper began to decompose at about 160° F.

Experiment 10.—Solution of chloride of cobalt and hydrochloric acid. No current was produced by heating.

Experiment 11.—In an additional and somewhat different experiment, suggested to me by Professor G. G. Stokes, a bent glass tube, U shaped, was filled with a nearly saturated solution of subchloride of copper in partly diluted hydrochloric acid. Two perfectly similar electrodes, cut from contiguous parts of the same sheet of pure copper, were connected with the galvanometer, then suspended in the liquid of the two limbs, and one of the limbs gradually heated by means of a surrounding water bath to about 210° F. The heated piece became gradually and increasingly positive to the cold one, and acquired a coating of minute crystals of metallic copper. The heating occupied about five minutes; but by continuing it ten minutes longer, the current gradually and largely decreased.

Extensive investigation would be necessary in order to ascertain to what causes the currents produced in these cases are due.

* Paper read before the Birmingham Philosophical Society, June 11th, 1885.

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GLAESENER SECONDARY BATTERY.

All inventors—or rather devisers—of electrical accumulators or secondary batteries endeavour to obtain a maximum of surface with a minimum of weight in their electrodes. MM. Glaesener Freres, of Châtillon, near Arlon, in the Belgian province of Luxemburg, seek to attain this desideratum by rolling continuous bands or tapes of lead, having minute projections on both surfaces, so that, when wound spirally into a disc, they permit of the liquid passing freely between them. They assert that their accumulator is the lightest for a given duty of any hitherto brought out on the Continent. This battery has lately been brought into notice through its application to the lighting by Swan lamps of the Luxemburg Prison, which will be referred to below.

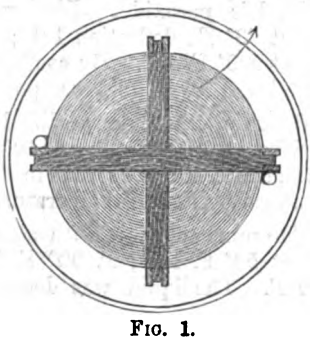

FIG. 1.

The lead tapes forming the electrodes are:—1 centimetre or 0·4in. wide, and about 0·4 of a millimetre thick, having on both sides small hemispherical projections, varying from 0·1 to 0·5 of a millimetre in diameter. Each tape 30 metres, or nearly 100ft. long, is wound spirally, so as to form a disc of 5in. diameter, weighing 1,200 grammes, or 2lb. 10oz., and presenting an effective surface of, on an average, rather over 62 square decimetres or six square feet, 100 square inches. Although these electrodes are used without any coating, they lend themselves admirably to receiving a coat of red lead, which is held between the folds of the spiral. Besides, as soon as the accumulator begins to act the red lead is held more closely, on account of the expansion of the electrode and the consequent tightening of the spirals.

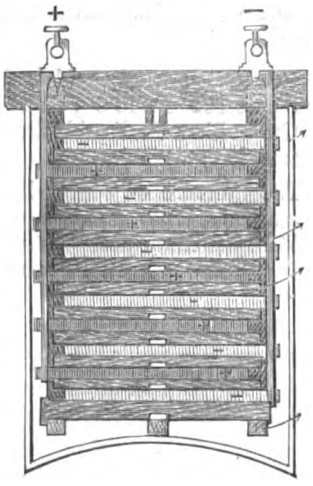

FIG. 2.

The discs are arranged, as shown in the accompanying vertical and horizontal sections, in a pile of 11, with wooden crosses between, coated with a highly insulating varnish. To the bottom cross, which is stronger than the rest, are pinned four wooden uprights, which are attached to the cover, provided with a handle, so that the whole may be inserted and withdrawn from the glass jar, containing dilute sulphuric acid. The outer ends of the electrodes, arranged alternately positive and negative, as shown in the section, are wrapped round vertical lead rods, put in connection with the binding screws. An electrode has been sent to us which has been in use six hours a day for more than a year, and the lead of which, though brittle, is not eaten through.

MM. Glaesener Freres lighted their own works at Châtillon about two years ago with twenty 10-candle Swan lamps, maintained by 25 accumulators, the lead of each of which weighs 6 kilogrammes, or 13lb. They are charged, from four to six hours a day, with a current of 55 amperes at 15 volts; and there has been no hitch hitherto. The next installation was at the Saint-Leger Roller Flour Mill, which is driven by water, so that no additional expense was incurred for the power absorbed. A small Gramme dynamo charges forty accumulators, the lead of each of which weighs 18 kilogrammes, or about 40lb.; and these maintain 16 Swan lamps. The installation cost, in round numbers, 1,500fr. = £60; so that, putting 10 per cent. for interest and depreciation, and 50fr. = £2 for maintenance and renewals, the expense of a year's lighting, for an average of 10 hours a night, is 200fr. = £8, or 6 centimes (about a halfpenny) an hour. This is just the same price that was before paid for paraffin; but the lighting is now 50 per cent. better, without counting the diminished risk from fire.

The prison at Luxemburg is lighted by twenty five 10-candle Swan lamps, distributed among the workshops, passages, and guard house, and maintained by 30 accumulators, the lead of each of which weighs 12 kilogrammes, or 26lb. They are charged by a Gramme shunt dynamo, of the workshop type, giving out 70 to 80 volts at 21 amperes when making 1,500 revolutions a minute. A charge of 70 to 80 ampere-hours is found sufficient for the lighting required, viz., a few hours every night, one lamp, however, being maintained all through the night. On one occasion, by way of trial, the accumulators, charged for an hour, by a current of 70 volts at 14 or 15 amperes, maintained a Swan lamp of 50 volts at 0·65 ampere for about 20 hours. The dynamo is driven by a broken-down old portable engine, the speed of which is so far from being constant that it certainly would not do for electric lighting, but for the accumulators acting as a regulator, and so maintaining a steady light.

THE BAZIN ROTATIVE BATTERY.

M. Hospitalier, in *L'Electricien*, gives the results of his experiments with the Bazin rotative battery as follows:—

Duration of discharge	4h. 30m.
Quantity	198,000 coulombs 55 ampere-hours
Total work disposable	1,218,900 joules 122,000 kilogrammetres 0·45 horse-hour (French)
Consumption of zinc (not including motor)	112·6 grammes
Mean consumption per cell	160·9 „
Effective consumption per ampere-hour	2·93 „
Theoretic consumption ditto	1·213 „
Mean force of battery during discharge	75 watts
Mean force of one cell	10·74 „
Maximum ditto	15 „
Initial E.M.F. (7 cells in series)	13·1 volts
Final E.M.F.	11·9 volts.

The battery thus experimented with consisted of eight cells, one of which served to rotate the zincs, &c., at a rate of about one revolution per minute whilst the other seven were coupled in series in the outer circuit. The results obtained are not very brilliant, but M. Bazin promises to furnish a more perfect form of his battery for future experiment, asserting that the one to which we have alluded was in an elementary form only.

THE ELECTRIC LIGHT AND VEGETATION. — Professor Holdefleiss has noticed that beet seed sown in soil which was exposed to the electric light germinated two days earlier than similar seed without the action of the electric light. Another interesting observation is that of Herr Scholler, who has noticed an exceptional luxuriance of beets in a small plot which had been struck by lightning.

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CONVERSAZIONE AT THE TECHNICAL COLLEGE, FINSBURY.

On Thursday, the 16th inst., a students' *conversazione* was held at the City and Guilds of London Technical College, Finsbury, about 600 members being present. There were several exhibitions of various subjects, and the whole of the arrangements, under the management of Mr. A. Newman Lawrence, were carried out in a satisfactory manner. Amongst those present as representing the council of the institute were Messrs. R. P. Barrow, Joseph Beek, Rokeby Price, J. Travers Smith, Robins, Jennings, Sawyer, and Mr. Phillip Magnus, the director and secretary of the institute. During the first hour, *i.e.*, from 7 until 8 p.m., the exhibits were graphically explained to the visitors, and the mode of working in many cases freely illustrated by experiment. In the basement there were exhibitions of mechanical apparatus and machinery; woodwork, lathes in motion; metal work, lathes and other machinery in motion; and steam engines (which supplied power for all the machinery and the electric light, there being no gas in the establishment). There were also dynamos at work lighting the building, and other stationary machinery. On the ground floor were to be seen students' drawings, heat apparatus, and some electrical apparatus, such as is used by the advanced students of the college; and a telpherage model at work. These of course attracted considerable attention, but not so much as the articles shown on the first floor. Those consisted of photographs, and various scientific instruments, microscopes, electrical apparatus, and a phonograph. On the second floor was a chemical laboratory, microscopes, respectropes, and polariscopes. These exhibits were open all the evening. In room No. 21, on the first floor of the college, a lantern exhibition was given. Prof. Silvanus P. Thompson, with his usual kindliness, conducted a series of optical and polariscopic experiments, and Mr. John Castell-Evans was equally deserving of thanks for his clear and lucid exposition of the mysteries of spectrum analysis and crystallization. A variety of lighter fare had also been provided. A concert, given by the Technical College choir and others, attracted a large audience, and a comedy drama, entitled "Alone," performed in the large hall by Messrs. F. Rawson, S. Williamson, Baker, Sulman, and the Misses Del'Orme with great effect, followed closely upon its heels. After an interval, dancing commenced in the large hall, and was maintained with great spirit until a late hour.

The arrangements were very ably carried out by the secretaries of the various departments. These were: Mr. F. Lewis and Mr. Southern (Exhibition Committee), Mr. S. Williamson (Dramatic Committee), Mr. F. M. Smith (Concert Committee), Mr. H. Codd (Decorating Committee), Mr. H. F. Marks (Dance and Refreshment Committee), Mr. Cockburn (fountain), and Mr. H. A. Lawrence (organising secretary).

LEGAL.

United Telephone Company (Limited) v. Bassano and another.

In the High Court of Justice (Chancery Division), before Mr. Justice North, this case was continued.

Professor Forbes was examined on behalf of the defendants. He said that at the date of Edison's patent the only meaning of "diaphragm" known was that which separates one part of a structure from another. His reading of Edison's specification was that it was essential to the invention that the diaphragm should be between the resonant chamber and the tension-regulator. He found nothing in defendants' instrument which corresponded to Edison's diaphragm. He had performed various experiments with defendants' apparatus, using first the whole, then the speaking trumpet and base detached from the wooden back board; then with the speaking trumpet and base detached, but with the pencils and blocks forming the tension-regulator composed of different materials; then with a speaking trumpet made of lead, then with a speaking trumpet made of soft putty and laid on a mass of straw, and so on, the results shown being that the desired telephonic effects were obtainable by means far removed from those designated by Edison in describing his invention of the diaphragm. The witness then went through Edison's specification, and discussed the various kinds of tension regulators there described. He stated that in all of them it was essential that they should be semi-conductive and compressible, as well as resilient. The defendants' instrument acted as a microphone. It consisted of pieces of carbon loosely attached to each other, and Hughes, who was the inventor of the microphone, always used them with a sounding-board. So used the microphone reproduced even the sound of a fly crawling on the board. Hard carbon was not a semi-conductor, but a good conductor of electricity for telephonic purposes; it was not a good conductor for telegraphic purposes, being, in fact, the worst of all the good conductors in common use.

In cross-examination the witness said: The state of knowledge as to telephonic engineering had vastly improved since the date of Edison's patent. The function of taking up the sound waves was not the sole function of the diaphragm shown in Edison's specification. There was also the compressing of the tension-regulator, which, however, was the result of taking up the sound waves, and no other function was described. Being asked as to the action of the annular base of speaking tube itself on the sound waves, he said it did not act in the same way as Edison's diaphragm, but only faintly and indirectly. That base would, however, if used without the speaking tube, act better with it. The shape of the piece of wood in the transmitting part of any telephone only signified in respect of degree. The back board in defendants' apparatus would perform the function of interfering with the sound waves and probably add to the vibrations of the rest of the instrument, and so act on the tension regulator. He did not suggest that, having regard to the functions to be performed, it made any difference whether the diaphragm was in front, behind, or at the side of the tension regulator, nor that the shape was material. According to his (Professor Forbes's) understanding of Edison's specification, his instrument would not act without a diaphragm or tympan as described by him.

Mr. Conrad Cook, consulting engineer, was then called. He described certain experiments from which he ascertained that the microphonic results could be obtained without the assistance of any resonating contrivance. His reading of Edison's specification was that the diaphragm should be of a non-resonant character, that it should be of a tympanic shape, and not be susceptible to moisture or atmospheric conditions. The wooden part of defendants' transmitter would answer those requisites very indifferently, and in his opinion the defendants' invention in that respect was not covered by Edison. Then his tension-regulators as described were such as would in all instances be sensibly compressible, and varying their electrical resistance under variations of compression. Hard carbon as used by the defendants would not possess those characteristics. In witness's opinion Edison's tension-regulators would not act without the diaphragm.

The witness was cross-examined at considerable length upon Edison's specification, and the report of a lecture on the telephone delivered by himself in 1879 before the Society of Arts. He agreed with Professor Forbes that, having regard to the descriptions of the telephones described by the various inventors, the shape of the wooden portion was merely a question of degree in each case. In his opinion Edison's tension-regulator would not be commercially useful unless used with the diaphragm described by him.

After the re-examination of Mr. Cook, certain experiments were carried out by the defendants, his lordship first making the statement that he did not regard the experiments as evidence, but merely as explaining and illustrating the descriptions given in the witness box. The putty transmitter supported on a heap of straw, the lead transmitter, and the solid block of wood were used in turn.

Mr. Shoolbred, telegraphic engineer, was then called, but was not cross-examined.

Mr. F. T. Hollins, a co-patentee with the defendants of the instrument alleged to be an infringement, was next examined.

Mr. G. H. Bassano, an electrical instrument maker, and one of the defendants, then gave his evidence. He found in Edison's transmitter a diaphragm consisting of a disc made of mica. There was in the invention of himself and his co-patentees no diaphragm as described by Edison. The function of the conical mouthpiece was to concentrate the air waves upon the tension-regulator. The function of the annular base was to hold the carbon blocks which support the carbon pencils. The function of the wooden back board was to support the whole instrument. Edison only recommended one material for the diaphragm—namely, mica—as being of a non-resonant character, that being essential because a resonant material would tend to resound only to its own pitch, and so interfere with distinct articulation. Edison further considered that the influence of moisture must be avoided, and he did not mention wood as suitable for a diaphragm. The characteristic feature of Edison's tension-regulator was that it should be of a semi-conductive material; hard carbon was not a semi-conductor but a good conductor. Hard carbon was elastic and therefore compressible to some extent, but not in the sense Edison intended. In defendants' tension regulator hard carbon was used, working by a microphonic action, however that operated, which was as yet a mystery.

In cross-examination, Mr. Bassano said that the conical mouthpiece in defendants' transmitter would take up the sound waves to some extent, and so with the base and the back board. The vibration given to those parts would certainly be imparted to the carbon blocks and the pencils. The result would be change of position in the carbon surfaces in contact, for there would be some pressure. The surface contact would vary to the extent of the compressibility of the carbon, and the resistance to the electric current would be varied synchronously with the variations in the sound waves. Defendants' transmitter was connected with a closed circuit, and the variations in the sound waves at the transmitting end would be reproduced at the receiving end.

This completed the evidence for the defence.

On Monday Mr. PLUMPTRE summed up the case for the defence, dealing with both the tension regulator and the diaphragm. He especially insisted that the plaintiffs' contention that, so long as a substance separated some-

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thing from something else and was capable of vibration it was a diaphragm within Edison's description, was untenable. Edison described in substance the mouthpiece and base, and what corresponded to the wooden back board of the defendants' transmitter, which the plaintiffs contended were, each and all taken together, a diaphragm, yet he in no way claimed those parts specifically; on the contrary, he described and claimed as a diaphragm something which was not used at all by the defendants, namely, a disc of mica inside the mouth-trumpet, and adjusted against the tension regulator. Experiments had shown that the defendants' tension regulators would act without any assistance except the current of electricity and the voice itself.

The ATTORNEY-GENERAL, in reply, submitted that the decision of the case must depend upon his lordship's view of the evidence. He drew attention to the fact that no attack had been made by the defendants upon the validity of Edison's patent, and pointed out that what they had attempted was to put a narrow construction upon Edison's description of and claim for the diaphragm. But it must be borne in mind that Edison's invention was in fact at the date of his patent a revelation in a particular branch af science, and what he did was either to discover new functions or a new adaptation of old functions. It would not be reasonable to expect him to have guarded in his specification against every possible adaptation of the principle of his diaphragm; but having discovered a new mode of manufacture he had described its esssential features, and the best mode of carrying it into effect. And it was impossible to adopt the essentials of that new mode of manufacture without infringing it, protected as it was by a valid patent. The specification of Edison showed that he never intended to confine the diaphragm to the special combination to which defendants' witnesses attempted to restrict it. It was not necessary to ask for a beneficent construction of the specification; Edison was describing the instrument by its functions. The defendants' instrument was one in which, to adopt the definition of Mr. Justice Fry, there are parts which separate the substance below from the air or substance above, and those parts perform the functions of Edison's diaphragm, and it was not disputed that it made no difference on the issue of infringement whether the diaphragm, whatever its form, was placed before or behind the tension regulator in relation to the voice. The learned counsel then pointed out that it was misleading to say that Edison used the term diaphragm in a special "telephonic" sense. What he did was to describe the diaphragm as adapted for telephonic purposes. Further, the evidence showed that the shape of the instrument was only a question of degree, and the same might be said of the material and the position. He unhesitatingly submitted that the cone and base of defendants' instrument was in every sense a diaphragm, and that was shown by their acting as a transmitter when merely used as a "toy telephone" or "lovers' telephone," with a piece of string and no electric current. As for the wooden back board, it operated as clearly as anything possibly could, to take up the vibrations of the voice. The use of a transmitter with those features was clearly an infringement of Edison's patent, so far as concerned its first feature of a diaphragm. As to the tension regulator, the defendants had in that respect also been guilty of infringement. Its function was to vary the amount of resistance to the electric current by greater or less surface contact, which may be done by contact, pressure, or compression, or all three, or any two of them. The defendants made use of the same means, but called it "mircophonic contact." Further, there was a concensus of opinion among the witnesses as to the mode of action of the tension regulator. Then it could not be contended that the use of hard carbon in the tension regulator was not included in Edison's invention. The defendants said they used hard carbon and that Edison used compressed plumbago, but it lay upon them to show that it did not act as Edison's compressed plumbago acted. Further than that, one of their own witnesses had admitted that compressed plumbago was in fact compressed carbon. Lastly, he submitted that the defendants' transmitter had been amply proved to be a combination forming a mechanical instrument which acts by picking up and sending on the sound waves exactly in the same way without any material differences as Edison's invention.

At the conclusion of the Attorney-General's speech his lordship reserved judgment.

COMPANIES' MEETINGS & REPORTS.

The Eastern Telegraph Company (Limited).

The twenty-sixth half-yearly ordinary general meeting of this Company was held on Thursday, July 16th, 1885, at the City Terminus Hotel, Cannon-street, London, under the presidency of John Pender, Esq., M.P.

The notice convening the meeting and the minutes of the last general meeting having been read,

The CHAIRMAN said: Gentlemen, you have had the report in your hands for some days, and I presume you will, as usual, take it as read. But, before moving the resolution approving the report, I shall make a few remarks as I have generally done on these occasions, and though, on the present occasion, your report is very full and complete in every respect, both in its accounts and in the paragraphs which give you information as to what has been done during the half year, still I will keep up my old custom and give you a more general review of the last six months' working of the Company. The revenue for the last six months, ending March, 1885, amounted to £371,682, as against £345,156 in the corresponding period of last year. This increase of £26,526 was owing, no doubt, to the large number of Press and Government telegrams sent in consequence of the military operations going on both in Egypt and India and the war between France and China. The total working expenses amounted to £91,599, against in the corresponding period of 1884, £90,482, or an increase of £1,117. The principal items showing increases and decreases are as follows: The general expenses in London have decreased by £1,085; the working expenses at the stations have increased by £2,959. The details of the various increases and decreases under this head are as follow:—Salaries and wages at stations increased £2,408. We have opened out four new stations during this period, namely, Perim, Piraeus, Patras, and Katacolo. There is also a full six months' charge for working the Suakin station against only four months in the same period of 1884. The repairs and renewals of furniture at the stations show an increase of £961. We have been obliged to take larger offices at Gibraltar to provide for the proper accommodation of the staff there, which was previously insufficient, and I may mention that we make Gibraltar to some extent a station for perfecting our young operators in the work which they are required to perform at the different stations in the Levant, or in the far East, if necessary. There are also several amounts in connection with different stations in the shape of furniture, &c., which make up the amount of increase mentioned. The repairs to stations have increased by £208, principally also at Gibraltar. There is a new office, and probably it is one of the best buildings in Gibraltar, and it had to be fitted up. In medical attendance there is an increase of £54. Rations and provisions show an increase of £226. But this was exceptional. We found at Suakin, where there was so much difficulty in obtaining food, and so much demand for the work, that it was absolutely necessary that we should feed our young people well, and keep them in such a state of health as to enable them to perform the onerous duties put upon them during the time of the operations there. In these days of progress, and being so closely associated with electricity, we have thought it well to introduce the electric light into our station at London, and that has cost us £362. We find where headwork is so absolutely necessary as it is in our operations, that it is most desirable, especially in small rooms, that we should have the air kept as clear and pure as possible, and we believe we can do that much more efficiently with the electric light than with gas. You see, therefore, that we lose no opportunity—in fact, we avail of every opportunity—to give efficiency to our system by keeping those who manipulate and carry on the work in as good a state of health as we possibly can. There are, on the other hand, some decreases in the following items:—Travelling expenses, £382; rent, fuel, and light, £175; expenses of land lines, £1,002; stationery and printing, £194. I may mention that the items of the use of patents, electricians' retaining fee, proportionate cost of Suez-Benha land line, and the construction of cable tanks at stations are the same. But I am glad to tell you that about this period the patent rights of certain patents we have been using—such as the "Mirror," and the "Recorder,' and other inventions of Sir William Thomson, who has been receiving during the last fourteen years, at least, a very handsome income from them—are about to expire, if they have not already expired. That will cause a reduction in our expenses of £3,000 per annum. But, in bidding good bye to these patents, I may say that we, and, in fact, the world at large owe a great debt of gratitude to Sir Wm. Thomson for those inventions, because they have enabled submarine telegraphy to be carried to a point which, I believe, would not have been possible without these inventions. I believe in the early stages of submarine telegraphy that had not the "Mirror" patent been invented by Sir Wm. Thomson, we should have been in darkness so far as the commercial working of that system was concerned. Therefore, while I part from him with the greatest possible pleasure, I would say that we are deeply indebted to him for the benefits we have derived from his great and grand intellect. There are a few other items that I have now to draw your attention to. There is one very important question, and that is the expenses attending the repairs and renewals of cables. They cost last half year £44,815, against £37,113 in the corresponding period of last year, being an increase of £7,702. The question of repairs has always been an important one; and, as our cables are naturally growing older, it must become still more serious. But we have tried in the conduct of this business to maintain our system in as efficient a mode as it was possible for us to do. We have duplicated a very large extent of our system, and we have done a great deal of that duplication and all the repairs out of revenue. That supplies us at the present moment with a very efficient system, but one at the same time which requires not only constant care and attention, but additional ships so as to enable us to have those ships placed at the proper stations in order to avail ourselves immediately of their services for effecting any repair, because, as you know, we are dependent for our income entirely on the maintenance of our system. If we can maintain that system what I would call consecutively—that is, so that there should be no interruptions to the traffic—we find that the use of submarine telegraphy grows steadily and rapidly in a time of good trade, or in a time of any disturbance, or war, or scare. To meet these requirements we must, therefore, not only have our system efficient in the way of duplications—or, I would say, triplications—but also by efficient ships on the spot, so as to do work if it is necessary. It will be seen on reference to the full details in abstract "C" that the work done by our ships has been very considerable. After charging all expenses, including income-tax, providing for interest or debentures, debenture stock, and preference shares, we are enabled to pay a dividend of 5 per cent, which, with the bonus, will make 6 per cent. per annum, and carry forward £100,000 to the reserve fund, against £65,000 at the corresponding period of 1884. On the other hand, we have written off these funds the discount on the issue of 4 per cent. mortgage debenture stock. That you will see is a very important item, and gave rise to a very considerable amount of discussion. But we thought it was better that it should be wiped off at once, so as not to saddle perpetually our income with it. The general reserve fund now amounts to £397,272, and the total reserve fund, including the Sardinian cable and other special reserves, is £431,705. I stated very fully when I last addressed you the percentage that this bore to the capital. I will not go into that matter

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to-day, but I may take an opportunity of doing so on another occasion, when we have tested the thing more than we have done yet. I may, however, state for your information that in 1877 we took £100,000 from the reserve fund in reduction of the cost of new cables; in 1878 we took £13,997, in reduction of the cost of renewals; in 1884 we took £300,000, towards the cost of new cables; and in 1885 we took £28,105, discount on the issue of 4 per cent. debenture stock, making a total taken from the reserve fund of £442,102. That amount we have applied to maintaining our system. But if we had kept that money in the reserve fund we should now have, instead of £431,000, nearly £900,000 in reserve We think, however, that we have done wisely in the course we have pursued, as it has enabled us to rather increase our traffic, and therefore maintain our dividends, as we now announce to you to-day. I referred in passing to the fact that some of our cables were getting old, and that during active times it was absolutely necessary we should maintain our system in a thoroughly efficient manner. Two or three months ago, as you are aware, there was an important scare, which I believe involved the late Government in an enormous expenditure. That was supposed to subside, and we were getting into smooth water again, and they were paying off forfeits in respect of many engagements into which they had entered. Only yesterday, however, there was another scare, which had a very serious effect on the stocks on the London market. How far that scare may have been justified or not I do not know, but it was a scare, and popular opinion seems to be on the side of the statement which caused it being a correct one. It is not my province here to give any opinion on political matters, but our position is to be prepared for scares, come when they may, and that we should have our system such as to meet the requirements of the Government, and at the same time add to our income by taking advantage of those scares. Therefore, I am going to shadow out to you to-day what we propose doing. We have now a duplicate system between Lands End and Malta. We go to Lisbon, Gibraltar, and Malta. Gibraltar and Malta are two very important strongholds in the Mediterranean. When we get to Malta we have many departures at that point, and we think above all that we should have that system thoroughly efficient. We have put by this time a very considerable amount to the reserve fund—£100,000; and that important income has come more, perhaps, out of those scares than out of legitimate traffic, which has not been so great during the last twelve months—our Indian traffic—in fact, in the last two or three years. But we are going through a cycle of bad times, and we are expecting a cycle of good times, and they will come soon when these scares cease. What we intend now is to triplicate our line to Malta, and then we shall consider ourselves in a most safe and sound position. I believe this will cost over £300,000, but I believe we can do the work partly from the reserve and partly from other sources in a way which will make our present position more stable and more permanent. I think we had better now continue for a time paying you a 5 per cent. dividend, with a bonus of 1 per cent., and strengthen our position so as to make it almost impregnable, than to pay you 7 or 8 per cent. now, and 3 or 4 per cent. next year. I put forward these views to-day because I think it is right that we should make our shareholders aware of our policy. We have a definite policy, and I think it important that both Governments and companies exercising such power as we ought to have a definite policy. We put our policy before you, and in that way enlist your confidence, sympathy, and support, in carrying out the work which we have to do. I show you that this triplication has become almost a necessity; but you will see it more when I tell you that at the present time we have the following breakages, which need not alarm you very much, because the arrangements we have made enable us to earn our income pretty much as if those breakages did not exist. The cables which are interrupted at present are the direct Porthcurno-Lisbon, the Gibraltar-Lisbon, the Suez-Suakin, the Suakin-Perim, and the Bombay-Aden (No. 1). I have never on any previous occasion stated to you the number of breakages, but still our traffic is going on by the arrangements which we have made, and probably a week hence we shall be able to report to you that all these cables are in working order again. We have the business thoroughly in hand. We know where the breakages are, and through the arrangements and efficiency of our ships we are able very promptly to carry out the repairs. These breakages have occurred since you had the report in your hands. Since I last addressed you we have closed a very satisfactory arrangement with the Greek Government, who are probably more in advance than any other governments that we have to do with in the establishment of submarine telegraphy. No doubt that is owing to their island kingdom, and they consider this necessary. We have just completed an arrangement with them for 34 years, that will give us £6,500 per annum upon an expenditure of 447 miles of cable.

A SHAREHOLDER: On an expenditure of how much?

The CHAIRMAN: The expenditure would be about £60,000, or £70,000, but a great deal of that cable is cable that we have more or less. In the course of our repairs we take it up and recast it, and we have always an amount of cable in that way which we can apply without saddling the capital. We are now dealing with Turkey, and probably before I address you next year we shall be able to say that we have made an arrangement with the Turkish Government for an extension to the Arabian ports of the Red Sea. We have done a great deal of work lately, and pleasant work too. Speaking of crazes, a great craze has come up on the part of Germany and France to possess colonies. They seem to look on the West Coast of Africa as a sort of Paradise, from the kind of quarrel which took place about it, instead of its being in the opinion of men who know the coast hardly a place where civilised men would stay to earn a livelihood. It has become notorious that the Government of Portugal has invited tenders for a cable to the West Coast of Africa. Our country—England—which has perhaps more important interests there than any other country, has been obliged to follow suit, and I hope we shall be able to report shortly that we have made an arrangement with the English Government to carry a West Coast cable from St. Vincent to the Cameroons, and probably further. But the inducements to carry it further are not yet very great. The Cape Colony have offered a subsidy which you may have seen in the newspapers, but it is not a subsidy which is likely to bring about an extension of cable to the point they aim at. As to the East Coast of Africa cables, we have had a curious experience. We have referred to it in the report. Curiously enough, since that line was established, we have had every year an interruption in the section from Zanzibar to Mozambique, much about the same time and much about the same place. It would seem to arise from some natural cause, which we could scarcely realise. But the result of our experience has been that we are now satisfied of the cause. Two great rivers run into the sea at that particular point, and we have found that the great rush of water from them undermined the land where the cable lay at the bottom of the sea at that point. Our cable left its resting place, and a break always occurred at the time of this flood. We are therefore duplicating that section of our cable, so as to satisfy the people of the Cape, who pay us a very handsome subsidy, and in order to satisfy the telegraph public generally, whose interests we consider almost first, and thus enable us to secure their traffic, and their confidence and support. That will cost us—or, rather the South African Company, in which we are large shareholders—about £120,000. I mention this because we are really the interested parties, and it will show you that we lose no opportunity of meeting the requirements of our customers. That £120,000 is to be paid out of the reserve of the South African Company, so it does not in the slightest degree reduce our dividends. I think I mentioned in the course of my remarks that we are indebted to the war both in China and Egypt for some of our earnings. Our colonies are so loyal, and so anxious to know what is going on here that when there is anything like a warlike movement in England you would be surprised how it quickens the desire on the part of our colonies to have telegraphic news. I am glad to see that, as it draws us closer to our colonies, and shows that we have a great field there, which we shall carefully try to develop. I think I have pretty well exhausted all I had on my notes, excepting this, that on the 10th of next month a conference, which is held every five years by the Governments of Europe, and indeed by the Governments of all the important centres of commerce and civilisation in the world, will take place; and they send to Berlin delegates to discuss the question of submarine and land telegraphy. The time has not yet come when they admit us into their counsels beyond the fact that we have one representative, I think; but we have found them upon the whole fair and reasonable. The delegates are open to our suggestions and our statements. Wherever we can show that anything we want done is in reason, we find they are disposed to support us. But there is a feeling abroad at the present moment, more particularly in Germany, headed by the Telegraph Minister there, a man of very great intelligence, and occupying a very important position, that submarine telegraphs should be more or less subordinate to the views and actions and policy of the land lines, and his idea is to have a universal system and a very low tariff throughout Europe—an idea that would not quite suit us. We have only to get the two questions fairly considered—the cost of a land line, and the cost of a submarine system—and we shall try and impress on our representatives there from England, who, I have no doubt, will take our view, and also to impress on the representatives of other nations our views, and endeavour to get them to deal justly and fairly by us. We hold that the land system, grand as it is, does not connect them with the world at large. We are the parties they are mainly indebted to for that, and we are entitled to the highest consideration from them. I am hopeful that we shall be successful, but if not successful in getting all our own way, it is still further necessary to triplicate our system. If you are to get a less tariff we must increase our system so as to enable us to carry the messages at reduced rates. This is a summing up probably of what I have said about our duplications, our triplications, and our ships. Altogether I wish you to understand that we are quite alive to the responsibility which rests upon us to maintain this system of submarine telegraphy, which we believe has done a very great deal already to revolutionise the world, and we hope to carry it still further in revolutionising the world still more for good. I now beg to move the following resolution:—"That the printed report "and accounts of the Directors to 31st March, 1885, submitted "to this meeting, be and the same are hereby received and "adopted; that a dividend on the Preference shares of the Company to "the 30th June, 1885, at the rate of 6 per cent. per annum be paid, less "income tax; and that, in accordance with the Directors' recommenda-"tion, a dividend be and is now declared of 2s. 6d. per share with a bonus "of 1s. per share, both free of income tax, on the Ordinary shares of the "Company, making, with previous payments by way of dividend on "account, a total payment of 6 per cent. on these shares for the year "ended 31st March, 1885."

The VICE-CHAIRMAN (the Marquis of Tweeddale): I beg to second that.

The CHAIRMAN: Before I put this resolution to the meeting, if any gentleman desires to ask any question of me I shall be glad to answer it before I ask you to approve of the resolution. No one rising to address the meeting, the resolution was carried unanimously. The Chairman further said: I think that closes the business of the meeting, gentlemen, and probably it is the first meeting that we have held at which we have not heard a suggestion. I like to hear suggestions, but we must suppose your silence is an approval generally of the policy of your Board.

Mr. MUIR: Before separating I would propose a vote of thanks to the Chairman and Directors for the way they have conducted the affairs of this great Company. I am sure you will all approve of that.

Mr. HURST: I wish to second the motion. I am very pleased to see the reserve fund standing so satisfactorily as it does, and I have no doubt that judiciously managed as our concern has been hitherto we shall still go on and become even a more flourishing company. We thought some

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years ago that we should do a great deal if we realised 5 per cent., but we have now gone on to 6 per cent., and the probability is that if we go on as we have done a still further increased dividend may be obtained, and the Company will still go on prospering.

The SOLICITOR (Mr. Burt) put the resolution, which was carried unanimously.

The CHAIRMAN: On behalf of my colleagues and myself I beg to thank you for this renewed evidence of your confidence, and I hope we shall continue to deserve it on all future occasions.

The proceedings then terminated.

The India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

The half-yearly general meeting of this company was held on Tuesday, at the Cannon-street Hotel, Mr. S. W. Silver in the chair.

Mr. TYLER (the Secretary) having read the notice convening the meeting,

The CHAIRMAN said they might consider that their sales were up to the average. They were certainly indebted to their indefatigable manager and excellent staff for the amount of business they secured. The portion that fell to their lot he believed was a fair one. Whether at home, on the Continent, or in the colonies they were well represented. As regarded cable sales, the returns at the end of the year would show a fair amount. They had in hand just now a contract for the Indian Government for 500 miles, which they would complete in the course of a month or two. One of their steamers had been employed in laying and relaying cables in the Gulf of Mexico, and another had been chartered by the Government for use in the Red Sea. With regard to the increased capital the new shares were taken up immediately, and he need not say that the capital had been serviceable to the Company. He moved the declaration of an interim dividend of 5s. per cent. or 10s. per share, free of income tax, payable on and after the 22nd inst.

Mr. NEIL BANNATYNE seconded the motion, which was carried.

A vote of thanks to the Chairman and Directors terminated the proceedings.

Anglo-American Telegraph Company (Limited).

Report of the Directors to the half-yearly ordinary general meeting of the proprietors, to be held at the City Terminus Hotel, Cannon-street, London, E.C., on Friday, the 31st inst., at 12 o'clock noon precisely.

The total receipts from the 1st January to the 30th June, 1885, including a balance of £1,676. 14s. 8d. brought forward from the last account, amount to £142,256. 19s. 4d. The traffic receipts show a decrease as compared with the corresponding period of last year of £92,730, consequent upon competition, a reduced tariff, and continued depression of trade between Europe and America. The total expenses of the half year, including repair of cables, &c., as shown by the revenue account, amount to £51,913. 13s. 9d. The Directors, under the powers conferred upon them by the Articles of Association, have, before declaring the nett profits, set apart the sum of £50,000 to the renewal fund, leaving a balance of £40,343. 5s. 7d. One quarterly interim dividend of 4s. per cent. on the ordinary stock, and of 8s. per cent. on the preferred stock, was paid on the 1st May, 1885, absorbing £14,000, and a second quarterly dividend of 6s. per cent. on the ordinary stock, and 12s. per cent. on the preferred stock, will be paid on the 1st August, 1885, absorbing £21,000, leaving a balance of £5,343. 5s. 7d. to be carried forward to the next account. The Company's repairing ss. "Minia" has been engaged during the past half year in the repair of the main cable of the Direct United States Cable Company, and the main cable of the Paris and New York Telegraph Company. She is now at work upon the repair of the Western Union Telegraph Company's cable (broken off the Great Bank of Newfoundland), having been chartered to that company for the purpose. The "Minia" has also restored communication upon the Brest-St. Pierre cable, laid in 1869, which was broken at 240 miles from the French coast. The Company's four main cables are in good working order, but the Duxbury cable, Northern Placentia, and Island Cove cables are all broken in shallow water. The interruption of communication upon those cables, however, does not interfere with the prompt transmission of the traffic, as alternative routes exist. The stockholders will have seen from the official reports circulated by the Company of the proceedings at recent half-yearly general meetings, that the Directors have been severely criticised and strenuously opposed on account of the policy adopted by them some years ago (with the full knowledge and sanction of the stockholders), of placing an annual contribution of £150,000 to the credit of the renewal fund, in order to provide for the replacement of the cables as and when they are worn out. In order to absolve the Directors from the charge of having needlessly deprived the stockholders of dividends, fairly and honestly earned, it has been thought desirable to explain the reasons which have induced the Board to adopt a policy which has latterly met with so much opposition. Without any technical knowledge of submarine cables, it must be obvious to all that from the hour of submersion they are subject to special depreciation, and consequently that the duty of the Directors of such undertakings is to ascertain, as far as practicable, the number of years the cables are likely to last, and to make reasonable provision for their renewal. For many years previous to the amalgamation in 1873, the position of the various companies was so uncertain, and the experience of submarine cables so limited, that the accumulation of a renewal fund upon any fixed principle was impossible, and it was not until after that date that the present system was commenced, and consequently, in order to make up for lost time, a much larger annual sum has hitherto been necessary than would have been required had the accumulation commenced from the date the cables were submerged. The amount which appears to the credit of renewal fund in the present half year's accounts is £788,331. 18s. 3d., and the Directors, having again carefully considered the matter, have come to the conclusion that unless some extensive replacement of cables becomes necessary in the meantime the contribution from revenue to that fund during the current year and the two following years may be taken at £100,000, instead of £150,000 as heretofore, and they trust that after the expiration of that period a still further reduction may be made. The proposition made at the last general meeting by one of the proprietors that the interest of the fund should be paid by way of dividend, cannot be adopted, as the amount set aside in each year has been based upon the principle of a sinking fund, which necessarily includes compound interest. The reduction of tariff to 1s. 8d. per word, commenced on the 24th December, 1884, in consequence of the opening of the Commercial Cable Company, still continues in force; the result is that none of the companies engaged in carrying telegraph traffic across the Atlantic are earning any substantial dividend.

The Cuba Submarine Telegraph Company (Limited).

Report of the Directors for the year ended 30th June last, to be presented at the twenty-eighth ordinary general meeting of the shareholders, to be held at the Company's offices, 61, Old Broad-street, E.C., on the 29th inst., at one o'clock precisely.

From the statement of accounts it will be seen that the gross receipts (including the tax returned by the Spanish Government and the balance brought from last account) amount to £21,447. 0s. 3d., and the gross expenditure (including the half of the annual payment on account of the 1881 cable, and the amount expended on cable repairs) to £6,136. 2s., leaving a sum of £15,310. 18s. 3d. to the credit of revenue account. Of this the sum of £3,500 has been added to the reserve fund, increasing that fund to £65,000. After providing for the preference dividend a balance of £8,810. 18s. 3d. remains, out of which the Directors recommend the payment of a dividend on the ordinary shares at the rate of 10 per cent. per annum, free of income tax, which will absorb £8,000, and leave £810. 18s. 3d. to be carried forward to the current half-year's account. The Directors have much pleasure in reporting that all the cables have continued in good working order, excepting one of the Santiago Harbour lengths, which underwent some slight repairs in February. The Director who retires from the Board at this time is Mr. Neil Bannatyne, who, being eligible, offers himself for re-election. Mr. Thomas Greenwood, the auditor, also retires, and offers himself for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JULY 22.		BUSINESS DONE WEEK ENDING JULY 22. Highest.	Lowest.
Anglo-American	27,	28	27¼	26
Do. Preferred	47,	48	47½	46
Do. Deferred	7,	8	7⅞	7⅛
Brazilian Submarine	11,	11¼	11½	11 1-16
Cuba	12⅛,	12⅜	12½	12⅛
Do. Preference	18,	19	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	12,	12½	—	—
Direct United States Cable	8½,	9	9	8⅛
Eastern Telegraph	11⅛,	11⅜	11⅜	11⅛ x.d.
Do. 6 per Cent. Preference	13⅛,	13⅜	13⅜	13⅛ x.d.
Do. 5 per Cent. Debentures, 1899	107,	110	—	—
Eastern Extension	12⅜,	12⅝	13	12 11-16 x.d
German Union	9⅛,	9⅜	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7 3-16	6⅞
Do. Preference	12⅞,	13⅛	13⅛	13
Great Northern	13⅞,	14⅛	14⅛	13⅞
Indo-European	31,	32	31	—
Reuter's	7½,	8	—	—
Submarine	185,	195	—	—
West India and Panama	¾,	1	—	—
Do. 1st Preference	8⅛,	8⅜	8 5-16	—
Western Brazilian	6⅛,	6⅜	—	—
Western Union 7 per Cent. 1st Mortgage	120,	124	—	—
Do. 6 per Cent. Sterling Bonds	103,	105	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅛,	¼	¼	—
Oriental	⅛,	¼	—	—
United Telephone	11⅛,	11⅜	11⅜	11⅛

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	—	—
Do. (fully paid)	3,	3½	3½	3⅛
Hammond Light (£3 15s. paid)	⅛,	¼	—	—
Swan	⅜,	½	—	—
Maxim-Weston	⅛,	—	—	—

MISCELLANEOUS.

Telegraph Construction	36,	37	36½	36½ x.d.
India Rubber, Gutta Percha, and Telegraph Works	24,	25	24¼	24⅛

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NOTES.

NOTICE OF REPAIR. — Telegraphic communication with Suakin is re-established.

THE TELEPHONE IN RUSSIA.—We hear that a considerable impetus is to be given to the telephone industry in Russia.

THE SUBMARINE TELEGRAPH CABLES BILL.—In the House of Commons on Monday last this Bill was read a third time and passed.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 24th inst. were £2,687.

THE POST OFFICE TELEGRAPHS.—The telegraph wires at Rood Ashton, Wiltshire, are being extended from Yarnbrook to the residence of Mr. W. H. Long, M.P.

NEW CABLE.—A telegram dated Paris, July 23rd, says that the Chamber of Deputies have passed the Bill for laying a telegraph cable between Senegal and Gaboon.

THE PERSIAN TELEGRAPHS.—The Persian Government intends constructing a telegraph line between Meshed and Sarakhs. The greater part of the necessary material is ready.

DEATHS BY LIGHTNING.—During a violent thunderstorm on the 22nd at Torre Cajetani, a small market town in the neighbourhood of Anagni, thirteen persons were killed and twenty-two severely injured by the lightning.

A NEW ELECTRIC RAILROAD.—St. Louis is to have an electric railway ten miles long. The system to be used is that of Dr. Wellington Adams, and a company has already been formed in Missouri to carry out the work.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending the 25th inst. were £2,155, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE EARTHQUAKES.—Three shocks of earthquake have occurred in Rungpur, Bengal Presidency, causing serious damage. A village near Nattore has sunk completely into the earth. A Reuter's telegram, dated Smyrna, July 30th, says that two successive shocks of earthquake were felt there shortly before six o'clock on the morning of that day.

THE LONGITUDE OF SENEGAL.—The result of the observations recently carried out with the object of determining the difference of longitude between the observatory at San Fernando, the Canary Islands, and St. Louis du Senegal is that the latter place is 1h. 6min. 2sec. west of San Fernando. Other computations have not transpired.

COUPLING BY ELECTRICITY.—The Louisville *Courier Journal* gives an account of a South Carolina genius who claims to have invented a perfect system of car coupling by electricity. Upon a recent trial a luggage train, it says, was in four pieces and coupled up without the aid of any person except the guard, who did the entire work from the brake van.

THE INTERNATIONAL TELEGRAPH CONFERENCE. — Mr. Floyer has left for Berlin to represent Egypt at the International Telegraph Conference, which will probably be opened on the 10th August. The first question for deliberation will be the propriety of introducing a uniform international tariff, a measure which is especially desired by Germany.

ANOTHER WONDERFUL BATTERY.—Messrs. Kauffer and Goldner, of Boston, U.S.A., have, it is said, succeeded in producing a battery of nine cells, which will light two 8 c.-p. incandescent lamps for 150 hours out of 300. The lamps have, we are informed, been burning more than a third of that time, and as yet the cells show no signs of being exhausted.

OUT OF IT.—Recently in Philadelphia an old woman drank a wineglass of battery fluid composed of sulphuric acid, sulphate of copper, and bichromate of potassium in mistake for a dose of tonic bitters. The internal resistance of the unfortunate woman not being equal to the E.M.F. of the battery, the result was a break of continuity, for which in this life there is no remedy.

A LOCOMOTIVE STRUCK BY LIGHTNING.—A singular accident recently happened, says the *Scientific American*, at Milnes, Va., on the Shenandoah Valley road, when the locomotive of a freight train which was standing on a siding was struck by lightning. Both the engineer and fireman received severe shocks, the engineer being so injured that he did not recover for several days, and the engine was somewhat damaged. Accidents of this kind rarely happen.

THE FRENCH TELEGRAPHS.—The French Minister of Posts and Telegraphs has authorised the establishment of telegraph offices in the following communes:—Castlenau d'Estretefonds, Saint-Jory (Haute-Garonne); Saint-Août (Indre); Gizeux (Indre-et-Loire); Villemontais (Loire); Frayssinet (Lot); Gesté, Jallais (Maine-et-Loire); Marinviller (Meurthe-et-Moselle); Cercié (Rhône); Aillevillers (Haute-Saône); Romenay, Saint-Julien-de-Civry (Saône-et-Loire); Courlon (Yonne).

AN IMPROVEMENT.—After the 15th of September next the electric light apparatus in the lighthouse at Cape Griz-Nez, which gives an alternate white flash and eclipse of 30 seconds' duration, will be replaced by a larger apparatus flashing three white rays and one red ray. The three white rays will be arranged so as to follow each other with great rapidity, there being an interval of about 12 seconds after the third flash, and in the middle of this—that is to say, at the sixth second—the red flash will appear.

"—— MELANCHOLY, SLOW."—Who is responsible for this? A telegram was handed in on Tuesday last at one of the metropolitan stations of the Post Office Telegraphs for despatch to a suburban locality some five miles distant. This was at 1:40 p.m., and the message did not reach its destination until seven minutes past eight on the following morning. If that is the way the Post Office transacts its business under the conditions of the present tariff it had better leave sixpenny telegrams alone.

ELECTRIC HEAD-LIGHTS IN AMERICA.—The Lehigh Valley Railroad has contracted for the equipment of its engines with electric head lights, subject to certain tests that are to be made between Easton and Jersey City at an early date. The dynamo is run by a small engine of 1½ horse-power, attached to the side of the regular boiler, and fed by it. The invention is a Western one, manufactured and controlled by a company in Ohio. It is already in operation on the Pan-Handle Railroad west of Cincinnati.

ECOLE SUPERIEURE DE TELEGRAPHIE.—In conformity with the decision of the Minister of Posts and Telegraphs given on the 22nd inst., l'Ecole Supérieure de Télégraphie will be opened in Paris, Rue de Grenelle, Saint Germain, on the 22nd of next September. Applications for admission to the courses to be addressed to the Minister of Posts and Telegraphs before the 1st day of that month. The *Journal Officiel* of the 25th inst. publishes in full the conditions and regulations under which admissions are granted.

BOOKS RECEIVED.—"Electricité a L'Exposition Universelle d'Anvers," par Charles Mourlon, No. 1; "Bruxelles Imprimerie du Mouvement Industriel. Well got up, and well worth

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reading. M. Mourlon has commenced his task in the right way, and by clear, though somewhat brief descriptions of the Ochorowitz microphone, the Van Rysselberghe system of simultaneous telegraphy and telephony, the Redon call bell, and other useful inventions of comparatively recent date, has made up a very readable number.

THE EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY.—Notice is given that the second annual general meeting of the Edison and Swan United Electric Light Company will be held at the Holborn Viaduct Hotel, London, E.C., this day (Friday), 31st inst., at 1:15 in the afternoon, for the purposes following, namely:—To receive and consider the annual statement of accounts and balance-sheet, and the report of the directors and auditors thereon; to elect directors and auditors, and transact the other ordinary business of the company.

OBITUARY.—The death is announced of Mr. Gower, inventor of the telephone which bears his name. Mr. Gower left Cherbourg on the 18th inst. in a balloon, for the purpose of carrying out some experiments having for their object the perfection of a device for obtaining automatically a desired equilibrium of the balloon at different altitudes. The balloon, however, descended when some distance at sea, and the unfortunate gentleman, after floating for many hours, ultimately died from cold and hunger. The balloon was found by some fishermen several miles from Dieppe.

LIGHTING OF ASSURANCE OFFICES. — The Prudential Assurance Company have entrusted the lighting of their offices in Holborn Bars to the Electrical Power Storage Company, of 4, Great Winchester-street, E.C. When completed this installation will consist of 1,500 lights of 20 candle-power, and will be one of the most complete in existence, as in addition to the storage batteries—which will be capable of working the lights for ten hours—the Marshall engines will be powerful enough to drive all the lamps direct. Three multitubular boilers, each of 45 horse-power, will be fixed, and two horizontal engines.

UNDERGROUND WIRES IN AMERICA.—We are informed that the President of the Baltimore and Ohio Telegraph Company, July 1st, signed a contract with the Averill Insulating Conduit Company for placing the wires of the company underground. The work will be begun in Washington immediately. The insulating material in which the naked wires are to be laid is composed of pure silica and refined asphaltic cement. From experiments already made it has appeared that 1,600 wires can be laid to the square foot, the insulation being so perfect that the strength of four dynamos was not sufficient to affect it.

THE LIGHTHOUSE COMMISSION.—In the House of Commons recently Lord C. J. Hamilton asked the Vice-President of the Board of Trade whether Her Majesty's Government have had under their consideration, in the interests of science and of the maritime welfare of the country, the advisability of requesting Professor Tyndall to resume the position he recently occupied in connection with the Lighthouse Commission. Baron H. De Worms, in reply, said that in March, 1883, Professor Tyndall resigned the office of scientific adviser to the Trinity House, the Commissioners of Irish Lights, and the Board of Trade. He had made no application to be reinstated in that position.

A TELEGRAPHIC SCANDAL IN FRANCE.—At an electoral meeting at St. Die, in the Vosges, M. Charles Ferry, brother and fellow deputy of the late Premier, was roughly handled by M. Tony Révillon about Tonquin, and hissed when he said it was above all things necessary to have such a colonial policy as would checkmate England. M. Charles Ferry's report of the meeting representing himself victorious reached the *Temps* the same evening, but the despatch of M. Tony Révillon's friends to the *Justice* was delayed forty-eight hours. M. Révillon threatens an interpellation on this subject, but suspends it on the promise of M. Sarrien, the Postmaster-General, to make a searching inquiry. It would appear that M. Ferry's partisans are still powerful in the Vosges telegraphic offices.

ELECTRIC LIGHTING AT MARLBOROUGH HOUSE ON JULY 24. The total number of lamps fixed was 340, of which 280 were of 20 candle-power, in frosted globes, and 60 were of 10 candle-power. In the ball rooms some of the lights were attached to the existing candelabra, and others were fixed round the cornice. In the Indian room 10 candle-power lamps, silvered on one side, were placed inside the cases to illuminate the Indian jewels. The saloon was mainly lit by lamps suspended from the existing fittings, but effect was obtained from a row of lamps placed out of sight at the foot of the pictures. The lamps in the conservatory, music rooms, and passages were placed in tinted shades. The whole of the current for the lamps was supplied from accumulators placed in a tent in the garden. This is, we believe, the largest temporary installation which has yet been worked in England from accumulators, the cells being brought, ready charged, from the works of the Electrical Power Storage Company at Millwall, a distance of about six miles. The same company carried out the whole of the work.

PROFESSOR BELL.—A Washington newspaper correspondent says:—"Professor Bell, the inventor of the telephone, is a tall, well-formed man of perhaps forty-one or forty-two years of age. He has a big head, well set on a pair of broad shoulders. His forehead is high, broad, and full, and a bushy heap of glossy black hair stands up and back from it as though its owner had the habit of often pushing his fingers through it. He has a pair of velvety black eyes, very bright, and such as I should imagine could fill with the feeling of the soul behind them upon occasion. He has a dark complexion, a strong mouth and features, tending rather to the English cast. He has a slight English accent, talks well, and keeps his mind well in hand. He is a hard worker, and I am told he often works all night long when he has some experiment on hand in which he is deeply interested. Mr. Bell's workshop, or library, is in the top of his big house in Scott Circle. The whole floor seems to be given up to it, and books, telephonic apparatus, and files of papers take up the several rooms of which it is composed. It is a delightfully airy place, and it gets the cool breezes which come from up and down the Potomac."

THE ELECTRIC LIGHT FOR ILLUMINATIONS.—A most noticeable feature in the illuminations with which the festivities at Osborne were terminated on the occasion of the marriage of the Princess Beatrice, on 23rd inst., was the electric installation on board Her Majesty's yacht, "Victoria and Albert." It consisted of a group of one hundred incandescent lamps, arranged in the form of the letter B., surmounted by a coronet, the whole being suspended between the main and fore masts of the yacht. The lamps used on this occasion were obtained specially for the illumination from Messrs. Woodhouse and Rawson at a very short notice, and consisted of their 20 candle-power new filament 46-volt lamps. The electric current for the lamps was supplied by a Gramme dynamo, worked in H.M.'s gunboat, "Bloodhound," which was moored astern of the royal yacht, through electric cables passed between them. In addition to the above most effective device, a powerful naval searchlight of 25,000 candle-power was displayed, its pure

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beam of white light illuminating at intervals Osborne House, the grounds, and the various ships and yachts in the bay. The whole of the arrangements were carried out by the electric light staff of the Naval Torpedo School ship, "Vernon."

DETERMINING THE WORK OF ELECTROMOTORS.—In determining the working conditions of electromotors, the ordinary plan consists in applying the brake to the motor and varying the load as required. This, however, introduces a source of uncertainty, as the fluctuations which occur when the brake is the absorber of power cause variations of speed, and consequent fluctuating readings in the instruments. In order to overcome this difficulty, and to render the speed of the motor absolutely uniform, Professors Geyer and Denton, of the Stevens Institute of Technology, have devised an ingenious method, which gives excellent results. In order to make the work of the motor uniform, they cause it to drive a dynamo, the current of which is sent through resistance coils, which are kept at a constant temperature by the air circulating around them. This dynamo is mounted on the cradle dynamometer of Professor Brackett, and thus at the same time the power exerted by the motor is accurately measured. We have, therefore, a dynamo generating current for the motor, and a second dynamo as the absorber of power. By merely changing the resistance in the coils above mentioned, the work of the motor can be readily altered to any degree and kept uniform for an indefinite length of time. For testing purposes this method is evidently superior to the brake, and in addition permits of the use of a dynamometer specially adapted to dynamo and motor testing.—*Electrical World.*

THE WEAR AND TEAR OF TELEGRAPH CLERKS.—A London correspondent of the *Edinburgh Evening News* is informed that the estimates for the Revenue Department for the year ending 31st March, 1886, present a curious study, particularly that portion which deals with the pensioning of the telegraph service. "It has long been contended that the constant wear and tear to the ear of the click-click in the telegraph instrument, or what is technically known as sound-reading, exercises a most injurious effect on the brain tissues. Apart from the actual monotony of the ceaseless repetition, the tension of the auricular nerve is a strain bound to tell on any but brains of the toughest fibre, and the pension list just issued clearly emphasises the fact. For example, there are for the twelve months dealt with 34 cases of fresh pensions. Three are granted for old age, *i.e.*, to people over 60; 13 for diseases which are specified by some term which can be understood, such as phthisis or cardiac disease. The remaining 18, however, are described by such delightfully vague terms as mental incapacity, general impairment of health, cerebral anæmia, infirmity of mind and body, nervous exhaustion, nervous prostration, until, fairly worn out for a word which shall signify idiocy, insanity, this is at last boldly stated. It is, to say the least, strange that more than 50 per cent. of the pensions should be caused through de rangement of the nervous system, and it is likely to call for some inquiry."

ELECTRICITY IN MINES.—The Zankerode Electrical Railway was a good beginning in the application of electro-motors to the work of underground haulage. The success of this experiment has led to a further step being taken in the same direction, and we now have an excellent example of an important electrical mineral line. This line is now in operation at the Paulus-Hohenzollern Collieries in Upper Silesia. The line, which is 800 yards in length, has been constructed for a traffic of 500 tons of coal in ten hours. This result Messrs. Siemens and Halske have guaranteed. The electrical locomotive weighs two tons; it is controlled by a specially devised regulator, which is said to give great satisfaction to those in charge of the train by its prompt and certain action. The insulated conductor consists of flat iron bars, galvanised at the ends and connected by means of fish plates. This conductor is suspended from the roof upon insulators. Brushes on the locomotives take the current from the conductor. The line is connected with the generator by cables about 250 yards long. The generator is driven by a belt from the flywheel of the engine. The trucks weigh 10 cwt. each, and have a capacity of 11 cwt. The train is composed of fifteen trucks, so that the useful load hauled is a little over eight tons, and the whole load nearly sixteen tons. With this load a speed of 7½ft. a second is reached. With an empty train the speed is 12ft. a second. At present the output is not sufficient to require the maximum transport of 500 tons a day.

THE ELECTRIC LIGHT AND MICROSCOPY.—At the meeting of the San Franscisco Microscopical Society on 10th June, Mr. Banks gave an interesting demonstration of the electric light in its relation to microscopy. He first showed a miniature incandescent loop lamp actuated by a sulphuric acid and sulphate of mercury battery. For purposes of microscopical illumination, the incandescent electric light possesses the great advantages of extreme whiteness and intensity. With regard to the batteries actuating these lamps, there are still some difficulties to be overcome, but there can be scarcely a doubt that it is a question of only a short time when, with increased steadiness, duration of action, and cheapness of battery power, the electric light will be superior to all other methods of artificial illumination for microscopical and microphotographic purposes. Mr. Banks also showed under the society's largest microscope the electric spark in its passage between the terminals of a ¼in. spark induction coil attached to a Grenet bichromate solution battery. Two vulcanite slides had been prepared, on which were fastened adjustable platinum strips connected with the battery wires, and terminating in brushes of platinum wire of extreme tenuity. The electric fluid, in its passage from one terminal to the other, formed a very attractive object under the microscope. One of the slides was used to show the effect on the electric spark of interposing films of soot of different thickness. In its passage through these the current was deflected into meandering lines, around which scintillated showers of sparks. The particles of soot could be seen arranging themselves in symmetrical groupings around the terminals. In conclusion, Mr. Banks announced that he had sent for, and would soon be able to exhibit the Stokes-Watson apparatus for showing under the microscope the combustion of various metals in the electric arc. Their characteristic spectra can also thus be shown by the micro spectroscope.

ANGLO-AMERICAN BRUSH CORPORATION'S EXHIBIT AT THE ALBERT PALACE.—In continuation of our remarks on this subject we append the following:—The grounds are lit by means of 20 arc lamps, worked in series off a single circuit of wire in conjunction with 44 incandescent lamps, arranged in multiple series of eleven to a group, these latter being used for lighting the band stand. The arc lamps are those of the well-known Brush 2,000 c.-p. type placed on posts at a height of 22ft. above the ground; the incandescent lamps are those of the Victoria type of 20 c.-p., and are arranged inside the band stand, and fitted in coloured glass globes. This apparatus is worked by means of two No. 7 Brush machines, driven by one of Messrs. Robey and Co.'s 12 h.-p. nominal semi-fixed engines. Although this apparatus produces a very beautiful illumination in the grounds, yet it has been thought desirable for ornamental purposes to supplement the arc lights mentioned with 700 coloured incandescent lamps

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of 5 c.-p. each, which are hung in festoons between the posts which carry the arc lamps, and run on the multiple series system in groups of thirteen, all large and unsightly cables being dispensed with, which is a most important point in places such as this. The type of lamps employed for this illumination are 24 volt 5 c.-p. Victoria incandescent lamps, specially designed and manufactured by the corporation for this purpose. They are variously coloured, and the effect produced is very pleasing, giving complete satisfaction. For working these small lamps a No. 71 Brush machine, with patent laminated armature core, is employed, driven by one of Messrs. Marshall and Son's improved semi-portable engines, fitted with patent automatic expansion gear. The arrangement and fixing of these installations has been carried out under the superintendence of Mr. F. W. Clements, one of the assistant engineers of the Anglo-American Corporation, and reflects great credit on that gentleman's taste and skill.

THE BLACKPOOL ELECTRIC TRAMWAY.—A local contemporary says:—Mr. Holroyd Smith, engineer to the Blackpool Electric Tramways Company, and inventor of the system shortly to come into practical use under their control, has had the satisfaction of giving a genuine demonstration of the working capacity of his patented method. It is quite true that the experimental venture was limited by reason of the incompleteness of the tramway works, but in so far as it was possible to test the line of route available, it was made abundantly evident that the electrical arrangements were quite competent to create a "going concern." The experimental "runs" were made from the Foxhall Hotel to the Wellington Hotel—a stretch of ground in every way suitable to the test from an electrical point of view, but affording a singular witness to the limited character of our conveniences for vehicular traffic. Whether of chance or design, it seemed as though the entire vehicular traffic of Blackpool was concentrated on this one particular spot on the occasion of the experiments, and in view of this fact, as also the number of spectators present, the absence of any accident goes some way towards showing that the electrical motive power is so far under control as to be capable of avoiding risks even under abnormal circumstances. More than one possibility of danger arose during the afternoon, but the rapidity with which the electric car was drawn up averted harm. Mr. Holroyd Smith undertook charge of the car—a handsomely constructed vehicle—and was apparently entire master of the situation. When the work of connecting the car-motor with the generating machine had been completed, a trial trip was organised. In the hands of Mr. Smith the switch proved to be very effective, alternately moving and stopping the car at pleasure. The experiences of the ride were satisfactory in every way. The cars are elegant in design, light in construction, and altogether admirable in the accommodation they afford.

THE TELEPHONE AND FIRES.—In connection with the great fire in Shoreditch on Wednesday last we are informed that the first "call" was received at eight minutes past one o'clock in the afternoon at the Shoreditch station, when the firemen were warned that there was a large warehouse on fire in Holywell-lane. The manual was at once turned out, and the intelligence forwarded to Whitechapel and to Captain Shaw at Southwark. Five minutes later the serious nature of the message was verified by a telephone call from Messrs. De la Rue's premises, which are close by the fire. Four steamers were immediately turned out, and it was found upon their arrival that the building numbered 18, in Great Eastern-street, and occupied by Mr. J. Chessum, a builder, was thoroughly ablaze, and that while workshops, store, and engine and boiler houses had all become involved, the fire was already spreading to the cabinet making premises of Messrs. Fineberg and Friedman, at No. 18A. As it was seen that there were other premises in danger, a telephonic message secured the turning out of two steamers from each district of the metropolis, as well as the headquarters' steamer, and Captain Shaw proceeded himself to the scene in a hose cart conveying hose to the extent of 1,000 feet. In the quarter of an hour which had elapsed, however, in the circulation of the messages, the flames had spread over to the wholesale ironmongery premises of Messrs. Crossman and Co., at 20, Holywell-lane, comprised in a five-floored warehouse of considerable dimensions, and had also attacked two large unoccupied five-floored warehouses next door. Under these circumstances more help was again telephoned for, and this time four steamers from the different districts were ordered, the result being that steamers were on the spot at two o'clock from Southwark, Chelsea, Portland-road, Regent-street, Clerkenwell, Islington, St. Luke's, Scotland-yard, Camden Town, Holloway, Whitechapel, Hackney, Bethnal Green, Mile End, Bow, Poplar, Shadwell, Bishopsgate, Shoreditch, Tooley-street, Rotherhithe, and Waterloo-road.

TELEPHONE CHARGES IN DUNDEE.—Mr. E. J. B. Lowdon, electrician to the late Dundee and District Telephone Company, has written as follows to the *Manchester Guardian*: "My attention has been drawn to the report in your issue of the 10th inst. of a reply made by Mr. Mosley, the chairman of the Lancashire and Cheshire Telephone Company, to the deputation which had waited on the directors to ask for a reduction in the exchange rate. Mr. Provand appears to have urged that the success of the Dundee and District Company, which charged only £10 per annum when it started and £5 afterwards, proved that the Manchester rate of £20 was too high. To this Mr. Mosley is reported in your journal to have replied as follows: 'The work in Dundee was carried out in a way that in Manchester would be considered quite unsafe, and would be at once condemned by the officials of the corporation under whose control they had to work. The lines in Dundee were run in an immense long span, in order to avoid the cost of construction. Permanent ways of poles and standards, which were costly in construction and in maintenance, were not established. They simply ran single wires from roof to chimney in the cheapest and most simple manner possible, and in a way that certainly the Lancashire and Cheshire Company would not lend themselves to.' In reply to the above I have to state that they are altogether uncalled for and altogether untrue. The wires here are as well put up, if not better, than those in Manchester. The position and length of stretch have all to be submitted to the town surveyor, and have to get his approval as well as that of a Committee of Council. Our spans are mostly shorter than those of the National Company, which occupies the same position here that the Lancashire and Cheshire Company does in your city. Our permanent ways will stand as long as any telegraph wires that are put up, and longer than the National's. Our poles are put through the roofs, and not merely laid on and guyed, and there are no attachments made to chimneys in all the system under me."

SIXPENNY TELEGRAMS.—Dr. Cameron, M.P., has written a letter on this subject, in expectation that he may not be able to be present when the Telegraphs Acts Amendment Bill comes on for discussion. He says Mr. Shaw-Lefevre's scheme, with the amendments which he was prepared to accept, would have given us a halfpenny per word tariff, under which groups of five letters or figures would have been reckoned (as in international telegrams) as single words, and the minimum charge

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would have been 6d. Lord John Manners, after his minimum, proposes the same halfpenny a word, and the sole difference between the two proposals is that while Mr. Shaw-Lefevre proposes to allow the sender to divide his twelve words between address and message as he pleases, Lord J. Manners will only allow him to send three words, or 1½d. of message, and compels him to take out value for the remaining 4½d. in a free address, of which many years' experience has enabled us to predicate the exact average length, and the fact that it will contain a number of absolutely useless words. Dr. Cameron remarks that as, in 1876, Lord J. Manners gave way to a decision of a Select Committee of the Commons, and abandoned the increase of charge then proposed, so he has no doubt but that in 1885 he would yield to an adverse decision of the House, and adopt a well-considered scheme approved by the Department over which he has been called to preside rather than render useless for an indefinite time the capital expenditure of £500,000, and the annual cost of £60,000 for salaries incurred in preparing for the introduction of 6d. telegrams. Dr. Cameron is certain that nine persons out of every ten who compare the competing schemes will decide in favour of that which allows the sender to distribute his twelve words between address and message as he likes, and against one which, while practically giving but the same number of words, imposes restrictions upon them which will prevent their use to anything like the best advantage, and will perpetuate the costly extravagances of the present system, admitted without exception by every practical Post Office telegraphist who has written or spoken on the subject.

Colliery Explosions and Earthquakes.—Now, says the *Colliery Guardian*, when the North of England Institute of Mining Engineers is occupied in tracing the connection between earthquakes and colliery explosions, and the minds of many are turned towards the subject, it will be found interesting to set out some of the facts connected with these natural phenomena that have already been observed. There is a coincidence of time in the occurrence of colliery explosions and seismic disturbances worthy of attention. The researches of Otto Volger have already established this fact. The relative frequency of shocks in winter and in summer is clearly seen in the tables which he publishes, and the difference for the several months of the year is so striking that it cannot fail to suggest, even to the careless observer, a relation to the colliery disasters. Of the 1,230 shocks which have occurred in the Alps during the course of his observations, 774 have happened in the autumn and winter months and 456 in the spring and summer months. These numbers are to each other as 1·69 is to 1. This division, however, does not show the relative frequency of these shocks in the most striking nor in the most instructive circumstances. The number of shocks in spring and in autumn are about equal, but in winter the disturbances are three times more numerous than in summer. Their distribution in the months of the year are as follows:—In January, 150; in February, 143; in March, 138; in April, 119; in May, 58; in June, 54; in July, 40; in August, 47; in September, 117; in October, 111; in November, 85; in December, 168. Volger states that of the 98 shocks which have occurred in Le Valais since 1856, 72 have happened in winter, and only 1 in summer. He remarks further that these disturbances are more frequent between sunset and sunrise than during the daytime. Of the 502 shocks in Switzerland, the exact time of occurrence of which has been recorded, 320 have happened at night and 182 during the day. From these figures it appears that—for that locality, at least—earthquakes are nearly twice as frequent in the night time as in the daytime. To determine this question in a general manner, he has tabulated the shocks which occurred in the two hemispheres in the years 1855 and 1856 of which the times are known. The result is that 300 appear under the head of "night," and 172 under that of "day." Other writers have observed and recorded the same fact for various localities.

The Cape Government and the Proposed Alternative Cable.—On June 26 Mr. Upington moved "That the House go into Committee to consider the motion for alternative cable communication between the colony and England, *viâ* the West Coast." The hon. mover said, in placing this resolution before the Committee, he thought he might fairly state that this was a matter of very considerable importance to the colony, especially considering what had recently taken place. The arrangement entered into with the telegraph company was that the large sum of £15,000 should be paid annually from 1879, as a subsidy, to provide cable communication between this colony and England. Though he had no desire whatever to reflect on this company, on more occasions than one the colony had been left without cable communication for a very considerable period—a longer period, possibly, than circumstances justified. If, at a reasonable expense, they could get a competing company to establish another line it would be a benefit to the colony, as the cost of messages would possibly be reduced by one-third or one-fourth. Furthermore, the advantage of having another line to fall back upon, in the event of one being broken, would be incalculable. The Government was not bound down to negotiate with the particular company mentioned. Some months ago the company communicated with the Government, through the Agent-General, requesting leave to land their cable on the coast, and the Government gave its consent. So far as he could judge—on reference to a chart before him, for the use of which he was indebted to the hon. member for Cradock—the company had already come a long way down the West Coast, and, instead of laying their cable in deep-sea water, seemed to have hugged the shore almost all the way along. Their proposal was to land at Port Nolloth, if any arrangement could be made with the Government, and the advantage of having land communication was greater than some people might think. It would be a great advantage for trade, as then information coming direct from England would not first have to pass through outlying portions of the country. A land line from Port Nolloth would cost from £25,000 to £30,000, and, for the use of this land line, the company might pay 5 or 6 per cent. per annum out of the subsidy granted by the Government. He would propose that the Government be authorised to enter into negotiations with some company for the completion of a West Coast line, with a subsidy of £7,500 per annum. The money so spent, he was satisfied, would find its way back threefold into the pockets of the people of the colony, in consequence of the advantage to be derived from the competition between two telegraph companies. At present the charge for messages was simply prohibitive, and the only way to reduce it was by competition. He would move that the blank in the motion be filled up with the words "£7,500." Sir Thomas Scanlen moved, as an amendment, that the words "with the India Rubber and Gutta Percha Company of Silvertown, or any other suitable company" be omitted. Mr. Jones moved, as a further amendment, that the subsidy be £5,000 which, after discussion, was withdrawn. Sir Thomas Scanlen's amendment was then put and agreed to, and the resolution as amended was put and declared by the chairman to be negatived, whereupon a division was called for, which resulted as follows:—Ayes, 31; noes, 25.

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THEORY OF MAGNETO AND DYNAMO MACHINES.

XXVIII.

Rotation of an Armature, taking Self-Induction into account.

The first approximation to the E.M.F. developed by the rotation of a Siemens armature in a uniform field was given in Art. XX., where the armature's own lines of force were neglected. We can now give a more complete investigation, and bring out more clearly the point already noticed in Art. XXVI., that the apparent resistance of the armature is greater during rotation than it is when stationary, a sort of spurious resistance being developed by the effect of self-induction in the commutated coils.

The fundamental relation is, we know, that if N be the total number of lines of force passing through a coil at any instant, the induced E.M.F. generated by varying that number is simply equal to their rate of change,

$$e = \frac{d\,\mathrm{N}}{d\,t}.$$

Now, N really consists of two parts—the lines due to the field, and the lines due to the armature itself; and these last are proportional to the strength of current flowing round it, being equal to $\mathrm{L}\gamma$. The lines due to the field depend on what sort of field it is, but if we consider it a uniform field of intensity F, and take the case of a Siemens armature with its component coils at all manner of angles to the line of force, the value of N is

$$\mathrm{N} = \Sigma(\mathrm{A\,F}\cos\theta) + \mathrm{L}\,\gamma,$$

L being the self-induction coefficient measured from brush to brush.

The rate of variation of the first of these two terms has already been discussed at length (*see* Art. XX.), and has been shown to be, if β is the angle been successive coils of the armature, and ω its angular velocity,

$$\frac{\mathrm{A\,F}\,\omega}{\sin\frac{1}{2}\beta}\cos(\omega\,t - \tfrac{1}{2}\beta)$$

which, for shortness, we will, as before, call E.

This E was the whole E.M.F. when there was no self-induction; but taking the complete value of $\frac{d\,\mathrm{N}}{d\,t}$, we find the actual E.M.F. generated by the rotation to be

$$e = \mathrm{E} - \frac{d}{d\,t}(\mathrm{L}\,\gamma),$$

or writing $\mathrm{R}\,\gamma$ for e, where R is the total resistance of the circuit, external as well as internal,

$$\frac{d}{d\,t}(\mathrm{L}\,\gamma) + \mathrm{R}\,\gamma = \mathrm{E},$$

or writing out the first term more fully,

$$\mathrm{L}\frac{d\,\gamma}{d\,t} + \left(\mathrm{R} + \frac{d\,\mathrm{L}}{d\,t}\right)\gamma = \mathrm{E}.$$

Here, then, we perceive as co-efficient of the current strength γ something more than the true resistance R, viz., a spurious or apparent resistance $\frac{d\,\mathrm{L}}{d\,t}$; and this can only be nothing if L, the self-induction of the circuit, is constant.

But L is not constant in a commutated coil, but is continually increasing, as shall now be explained. When the commutator gap belonging to a coil comes up to the brushes to be short-circuited the current in that coil is steady, and accordingly the removal of the coil from the main circuit effects no change in that circuit beyond a minute fall of resistance, which is quite probably compensated by the simultaneous restoration of a similar coil to the circuit on the other side of the brush. But when a coil is restored to the current again after short-circuiting, a current has to be started in it *de novo*, and so its self-induction entails a clear loss of energy. For every coil which passes the brushes the circuit thus acquires an extra amount of self induction, and in one revolution it acquires the amount L. This goes on uniformly, and so the rate at which the circuit gains self-induction, or $\frac{d\,\mathrm{L}}{d\,t}$, is equal to $\frac{\mathrm{L}}{\mathrm{T}}$ or $n\,\mathrm{L}$; and the above equation becomes

$$\mathrm{L}\frac{d\,\gamma}{d\,t} + (\mathrm{R} + n\,\mathrm{L})\,\gamma = \frac{\mathrm{A\,F}\,\omega}{\sin\frac{1}{2}\beta}\cos(\omega\,t - \tfrac{1}{2}\beta).$$

The solution of this equation is

$$\gamma = \frac{\mathrm{A\,F}\,\omega\cos\phi}{(\mathrm{R} + n\,\mathrm{L})\sin\frac{1}{2}\beta}\cos(\omega\,t - \tfrac{1}{2}\beta - \phi) + \mathrm{C}\,e^{-\frac{\mathrm{R}+n\,\mathrm{L}}{\mathrm{L}}t},$$

where $\tan\phi = \frac{2\,\pi\,n\,\mathrm{L}}{\mathrm{R} + n\,\mathrm{L}}$.

The second term in this equation may be neglected, as only representing initial disturbances which soon subside, and the rest may be written

$$\gamma = \frac{4\,n\,c\,\mathrm{A\,F}\cos(\theta - \frac{1}{2}\beta - \phi)}{\sqrt{\{(\mathrm{R} + n\,\mathrm{L})^2 + 4\,\pi^2\,n^2\,\mathrm{L}^2\}}},$$

c being half the number of commutator segments.

In Art. XX. it was pointed out that the effect of the commutator is to prevent a continuous change of θ; it is only allowed to vary through the angle β; and to get the maximum effect it is plain that the brushes should be set so that it may vary from ϕ to $\phi + \beta$. The variation part of the above expression may then be considered as practically unity, and the total E.M.F. obtained from the machine is

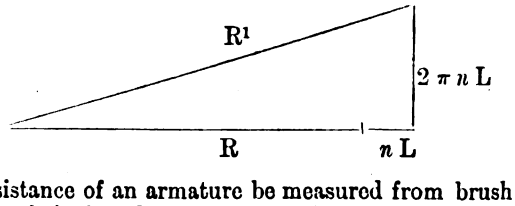
$$e = \frac{4\,n\,c\,\mathrm{A\,F}}{\sqrt{\left\{1 + \left(\frac{2\,\pi\,n\,\mathrm{L}}{\mathrm{R} + n\,\mathrm{L}}\right)^2\right\}}} = 4\,n\,c\,\mathrm{A\,F}\cos\phi.$$

Without self-induction this would have been simply $4\,n\,c\,\mathrm{A\,F}$, or E. But the actual E.M.F. is

$$e = \mathrm{E}\cos.\,\phi,$$

ϕ being the lag.

Instead of thus treating the effect of lag as a diminution of E.M.F., we may equally well regard it as an increase of resistance, and may say that, whereas the resistance of an armature in motion is really to all intents and purposes greater by the amount $n\,\mathrm{L}$ than when at rest, there is a still further, but still more spurious, increase of resistance of the whole circuit as soon as it is employed to produce a current, *i.e.*, when subjected to a periodic impressed E.M.F. The total virtual resistance R^1 is, in fact, the hypothenuse of a right-angled triangle, of which one side is $\mathrm{R} + n\,\mathrm{L}$, and the other $2\,\pi\,n\,\mathrm{L}$ R, being the real wire resistance of the circuit, with the armature at rest.



If the resistance of an armature be measured from brush to brush at rest, it is found to be r, say. If it be measured in motion, spinning n times a second, using a constant battery current in the usual way, and taking care that no earth's or other lines are cut during the rotation, the equation to the current is

$$r\,\gamma + \gamma\frac{d\,\mathrm{L}}{d\,t} = \mathrm{E}; \quad \text{or} \quad \gamma = \frac{\mathrm{E}}{r + n\,\mathrm{L}}$$

so the resistance then measured is $r + n\,\mathrm{L}$. But the effective resistance when the armature is actually producing a current by rotation in a field of force is a little greater still, being, as just shown,

$$\frac{r + n\,\mathrm{L}}{\cos\phi};$$

or,

$$\sqrt{\{(r + n\,\mathrm{L})^2 + (2\,\pi\,n\,\mathrm{L})^2\}},$$

which, in case r is much greater than $n\,\mathrm{L}$, may be written

$$r + n\,\mathrm{L} + \frac{2\,(\pi\,n\,\mathrm{L})^2}{r + n\,\mathrm{L}}.$$

With this last expression Ayrton and Perry's numbers agree much better than they do with their own formula $r + n\,\mathrm{L}$; in fact, if L be taken as 4·2 the agreement is almost exact.

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Results of Ayrton and Perry's Experiments on Resistance of Spinning Gramme Ring.

The resistance of the armature at rest was 1,768 ohms, and the increase at different speeds is shown in the following table, and compared with calculation :—

Revolutions. per second. n.	Observed resistance.	Observed increase of resistance.	Increase of resistance calculated from the formula $n\,L + \frac{2(\pi n L)^2}{r + n\,L}$	Calculated resistance.
0	1768	0	0	1768
10	1828	60	61	1829
20	1923	155	157	1925
30	2045	277	281	2049
33⅓	2103	335	338	2106

The agreement between observed and calculated resistances is almost exact; but probably this is only a coincidence. For the circumstances under which the resistance was measured by them (viz., with a steady battery current) ought to give the simple value $n\,L$ for the increase of resistance, and not the more complicated expression calculated above, which is the real effective resistance of an armature spinning in a magnetic field and producing a current.

One thing may be pointed out before closing, viz., that whereas the L in $n\,L$ means the self-induction of the armature, the L in $2\pi n L$ means the self-induction of the whole circuit; and this latter may be much greater than the other if the circuit contain electro-magnets or motors.

Separating the two L's, and denoting the one by L the other by l, the equation may be written thus :

$$L\frac{d\gamma}{dt} + (R + n l)\gamma = a\cos\theta,$$

or

$$\gamma = \frac{a\cos\phi}{R + n l}\cos(\theta - \phi),$$

where

$$\tan\phi = \frac{2\pi n L}{R + n l}.$$

The E.M.F. may be regarded as $E\cos\phi$, and the resistance as $R + n l$; or the E.M.F. may be regarded as having its simple value E, while the resistance of the circuit is

$$\sqrt{\{(R + n l)^2 + (2\pi n L)^2\}}.$$

The intermittencies of the current, and the effective resistance of the circuit, are therefore greatly increased when the external circuit has a high coefficient of self-induction, as, for instance, when the current is used to excite electromagnets; and a humming noise is accordingly heard from an electromagnet excited by a dynamo.

SUGAR REFINING BY ELECTRICITY.—Some further particulars as to this interesting process are to hand. On the occasion of the experiments recently mentioned by us, Prof. Friend, the inventor, ran through his machine several tons of a low grade West Indian sugar, producing in seven hours some forty barrels of refined sugar of the highest grade, every pound of which will prove to be nearly, if not quite, 100% pure. The particulars of the invention are, as follows:—The process is an electro-chemical one, which is worked by a machine, automatic in its action to a very great extent. As a paper-making machine is automatic, so is this in its working. Boiling and animal charcoal are entirely dispensed with. The process may, by comparison, be called dry. No syrups nor soft sugars of various grades are produced, the entire product being hard sugars, in whatever forms or sizes which may be desirable to produce, that is, from finest powdered up to and including cut and pressed loaf. One important feature in this manner of manufacturing must be observed—that all the saccharine matter in any parcel of raw sugar, is by this system rendered into hard sugar with a small loss, not exceeding 1% of the whole quantity.

ON THE "GROUPING SYSTEM" FOR THE DISTRIBUTION OF ELECTRICITY.

BY W. H. SNELL, A.S.T.E. AND E.

(Concluded from page 199.)

We have next to consider in what way the work of the batteries may be controlled from the engine room. It is evidently very desirable that the electrician in charge of the machines should be able at any time to ascertain the condition (so far at least as regards charge) of any one of the batteries. If this were done every morning he would be able to prepare a time table showing at what hour each battery should have completed its charge. The arrangement and apparatus described below might be tried for this purpose; but in the absence of experiments I do not of course express a positive opinion as to whether sufficiently accurate results could be obtained by the method proposed.

Each compensating room would be fitted with an instrument constructed and set up as follows :—An ampere-meter of some pattern which is read by the deflection of an index upon a horizontal scale has its index removed, and replaced by a counterpoised needle which projects beyond the scale. This needle carries a bridge of copper wire (or other suitable material) bent twice at right angles. The legs pass through the needle, and dip into two semi-circular troughs containing a saturated solution of $CuSo_4$, or other conducting solution. The troughs are concentric with the scale over which the needle moves. The inner trough is made of porcelain, the outer one of metal, preferably copper. This part of the apparatus is placed in circuit with a few Daniell cells. The current enters at the copper trough, and passes across the liquid to the copper wire which is carried by the needle; the resistance of this part of the circuit is thus practically the same, whatever may be the position of the needle. The current crosses the "bridge" and enters the solution in the porcelain trough. A copper electrode dips into the solution at each end of the trough, so that now there are two paths open to the current. The remaining connections are indicated in the diagram Fig. 2.

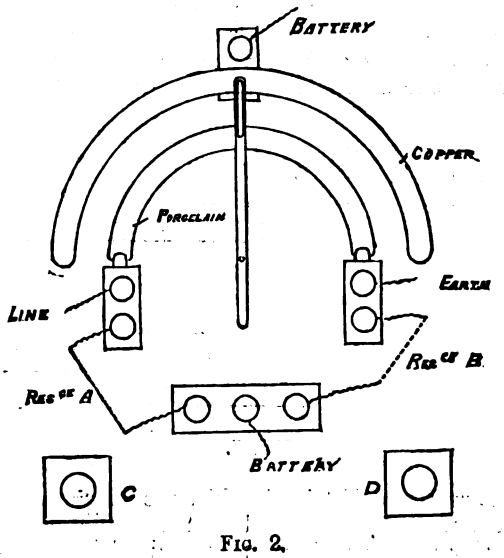

FIG. 2.

Resistance A = Resistance B (always). The Ammeter Terminals C and D are connected to the direct circuit of the secondary battery.

It will be seen that the solution in the porcelain trough occupies a position in the circuit of the Daniell's just similar to that of the wire in a "slide wire bridge," and that the wires corresponding to the galvanometer leads are taken to the machine room *viâ* "line" and "earth;" the "line" being an overhead wire; though probably it will be necessary to use a metallic circuit instead of an actual earth. At the machine room the current is taken into a voltameter provided with a graduated tube for collecting the liberated gas.

It will therefore be seen that if the ampere-meter be placed in the main circuit of the secondary battery the deflection of

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the needle in either direction will determine a current from the primary battery through the voltameter; and the quantity of gas liberated will be a measure of the number of coulombs which has traversed the secondary battery. Further, when the current is reversed in the secondary battery it is reversed also in the voltameter circuit. When this happens a polarised switch (in the machine room) falls over, cuts out the first voltameter and inserts a second. Thus the condition of the accumulator as regards available charge is ascertained at once by a comparison of the two voltameters. Of course in this comparison we shall make use of a coefficient expressing the rates, $\frac{\text{coulombs of discharge}}{\text{coulombs of charge}}$, or we may graduate the collecting tubes in this proportion, or we may adopt other devices for making the reading direct. All that is required from this apparatus is to give each day some fairly approximate idea as to the number of coulombs which each battery requires to complete its discharge. The readings would, no doubt, require to be supplemented at intervals by more accurate observations. These might, however, be taken in each battery room, say once a week.

We will next consider in detail the process of charging the cells.

Some difficulty is here presented. It will usually be stipulated that the current shall be continuously available in the lamps. Now, during the process of charging it will be necessary to increase the potential at the machine terminals very considerably beyond the normal value ($N E_2$). It will be remembered that E_2 has always been taken as the E.M.F. of discharge. And as, especially towards the end of the process, the E.M.F. of the cells will be considerably higher than that of discharge, it will be obvious (see also equation 28) that when the batteries are charged in this way we cannot use the current in the lamp circuit during the process.

The following plan offers a solution, and although it adds to the first cost of the system, yet it brings with it several other substantial advantages which may be placed as a set off.

First, let the battery in each compensating room be duplicated; then we may make use of the two sets of cells either alternately or both in parallel. Further, the connections may be so arranged that during the daytime, while one set is being charged the other set may be discharging *over the same main*. The E.M.F. of the dynamo may now be anything we please without affecting the difference of potential at the terminals of the lamps. The diagram Fig. 3 will make this clear.

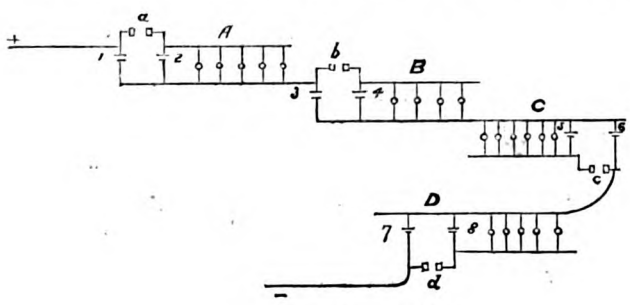


Fig. 3.

A and B represent districts in which the compensating rooms are situated at the positive end of the district, C and D are districts where they are the negative end. The switches, *a*, *b*, *c* and *d*, being open, batteries number 1, 3, 6 and 7 are being charged, and the lamps are being fed only by the remaining batteries. When the charging is completed the switches are closed, and one of each pair of batteries is disconnected. The lamps are then fed by dynamo and batteries together.

This solution does not quite hold good, however, for any compensating room which is not placed at one end of its district. In such cases it will be necessary to carry a separate charging main from this battery to the nearest battery in another district. This is shown in Fig. 4.

For charging we disconnect *a*—*b* and *b*—*d*, and join *b*—*c*. The lamps are not then in the dynamo circuit. For discharge (normal working) we reverse the above connections.

The additional advantages of this plan, which may be set-off against the extra outlay, are as follow:—

(1). The duplication of the cells affords a further security against breakdown.

(2). It helps to provide against any extra large demand for current.

(3). We may now more readily undertake to supply current for charging cells belonging to any customer by means of leads taken from any of the compensating rooms. This supposes that N has been taken small enough to allow the required margin for an increased E.M.F. of the machine.

(4). The batteries may be cut out of circuit one by one as soon as they are fully charged, and the E.M.F. and speed of the dynamo may be proportionately reduced, and as the number of ampere-hours required to complete the charge of batteries in the various districts may be expected to differ sometimes very widely, this should effect a substantial economy.

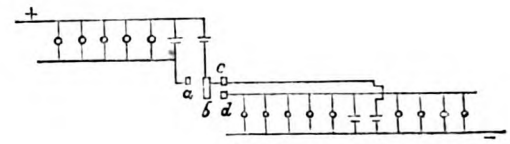


Fig. 4.

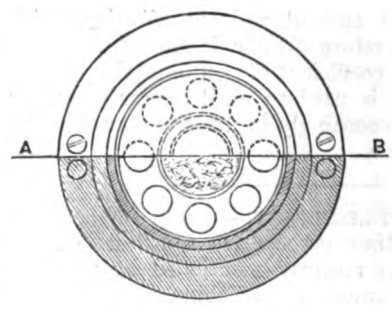
The voltameter observations will enable the electrician in charge of the machine room to determine each morning at what hour each battery will have completed its charge. By means of properly arranged switches placed on the same "line wire" as the voltameter circuit the required changes of connections may all be made from the machine room. It is not worth while to enter into detail at present upon this point, as the methods of arranging such devices are well understood. In practice it may turn out to be better to send a man to the spot at the proper time.

It is believed that all the essential points of the theory of the method have now been indicated. The system must evidently stand or fall mainly by the success or failure of the batteries.

THE BERTHON MICROPHONE.

The Compagnie Générale des Téléphones have for some time been employing a new microphonic transmitter, which possesses some interesting if not novel features. The variations of resistance in the circuit are produced in a packing of fragments

Fig. 1.



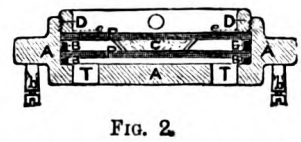


Fig. 2.

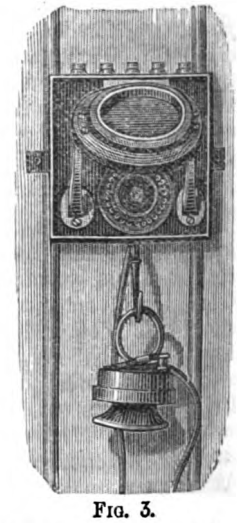


Fig. 3.

p p' are two circular carbon plates. B, an india rubber washer. C, the ring of ebonite containing fragments of carbon. A, circular ebonite box. O, opening corresponding to the diameter of the plate *p*. T T, openings pierced in the lower end of the box A. *b b'*, terminals to which the battery wires are attached (these latter are connected by platinum wires) to the carbon plates; and lastly B', a second washer separating the plate *p'* from box A, and allowing it to vibrate freely.

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of carbon, a method which has the advantage of permitting of an infinite number of contacts. The apparatus, as will be seen by our illustrations, is composed of two plates of carbon, of 1 mm. thick and 60 mm. diameter, maintained at a given distance by an india-rubber washer, B. Between these two is the packing of carbon, contained in a ring of ebonite, C. Its action is as follows:—Each of the plates communicates with one pole of the battery in such a manner that when the circular ebonite box, A, is inclined the current or lesser resistance according to the inclination. Upon a traverses the fragments of carbon, which offer a greater sound being given into the mouth of the apparatus the two plates are put in vibration, and transmit their movement under excellent conditions to the fragments of carbon in the ring C. The box A is fixed at an angle convenient for transmission, generally 50°, and after being so placed requires no attention whatever. Fig. 3 represents a simple and inexpensive arrangement of the apparatus.

CORRESPONDENCE.

[We have been requested to permit those who are interested in the matters referred to in these and previous letters to meet at our office on Wednesday next, August 5, at 11 o'clock, in order to discuss the best method to be adopted in carrying out the desired object. We have much pleasure in acceding to that request, and will place a room at the disposal of those who wish to attend.]

INVENTORIES EXHIBITION GRIEVANCES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is quite time some steps were taken on behalf of the exhibitors, as suggested by Mr. Joel. May I be allowed to add the experience of the company whose exhibit I represent? As far back as March last, in reply to a circular we stated the amount of current required to show our lamps and apparatus in action, but at the opening of the Exhibition no current was forthcoming, and we were then informed that, in order to obtain a current, a special wire must be run, which, after some delay with the engineer, we obtained. We were daily promised that our wants should be attended to. However, this has not been the case, the wire has not been run, and no explanation could be obtained until a few weeks ago, when we were informed that a current of half the E.M.F. required for our Talenta lamps would be provided from one of the Exhibition circuits if we carried out certain requirements. As one of these consisted in our purchasing and conspicuously fixing an automatic cut-out from a firm with whom we maintain an honourable rivalry, and as the principal feature of our exhibit is Hedges' fusible and automatic safety device, we thought this was going a little too far, so our stall remains unlighted. In conclusion, may I refer your readers to the remarks in the *Engineer* of last week as to the necessity of an organised system of trials of exhibits, which in our case would have probably upset the *ipse dixit* complained of? With apologies for trespassing on your space.—Yours, &c.,

THE GLOBE ELECTRICAL AND ENGINEERING COMPANY,
per H. T. Tomlinson, Assistant Manager.

20, Dartmouth-street, Westminster, July 29, 1885.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read the letters which have appeared in your last two issues on the above subject with great interest, as, being an exhibitor, the matter fully concerns me; but I consider the bad treatment to which we have been subjected has been very poorly exposed. It is very evident that many of the *employés* consider their position to be such that it affords them an excellent opportunity for tampering with the exhibitors' time and patience. Facts speak louder than words. I mention the first instance in which some of the clerks asserted their powers in the above respect. This was in the ticket office. I know a firm that consists of three members, and, naturally enough, they each took an interest in getting their exhibit in order. The man to whom the task was given to allot the tickets gruffly told one of the firm that only one ticket would be given, and this (with the usual condition printed on it that it was not transferable) was to suffice for the three. After a certain number of shillings had been paid and a great deal of trouble given, a letter to the secretary obtained a grant of one more ticket. With the success that these exhibitions obtain one would scarcely credit the extreme niggardliness in refusing to allow a ticket to each of the principals. But this may be the fault of the subordinates more than that of the governing body, and I think this likely. However that may be, I have never heard such complaining from exhibitors as at this Exhibition, and the Executive Council may be assured that there is something wrong to cause such discontent.

Another instance of the over-officiousness of the men employed by the authorities is the following, which I believe to be a fact:—A certain firm, in trying to accede to the request of the ticket-changer, sent a couple of workboys down to change two passes on Saturday at the proper time. Shortly after the boys returned with the message that the tickets had been cancelled, because the boys had been suspected of trying to get a view of the Exhibition while changing the tickets. What an absurd excuse; it merely shows the paltry reasons deemed sufficient for exercising the powers of annoyance placed in these men's hands. The firm to whom I allude inform me that they sent one of their assistants down to inquire into the matter, and explain that the lads had been sent to change the tickets in accordance with request; but he was informed that the tickets were cancelled and they could not renew them. A letter, however, to the secretary a short time ago had the effect of renewing the tickets without a word of explanation, When I think of the above instances of refusal to supply *exhibitors* with tickets except after giving all the trouble possible, I cannot help thinking what a useless thing it is to ask for tickets for friends. It seems, so long as the Exhibition is a success financially, that that is all that is desired, and those who have spent their money in making it must be content with a reluctant permission for themselves to enter. It seems to me that when the list of gifts is published a full list of exhibitors should be attached, with a note to the effect that it is through *their* money and *their* brains the Exhibition has succeeded, and that they have been denied (in some cases) passes for themselves, and in *all* cases for their friends, in order to bring about this happy result.

I could cite many more cases in which the officialism complained of has been exercised to as great an extent as those already mentioned, but it will probably serve no useful purpose to state them now. In many cases the secretary has been appealed to, and I must add he has always acted as fairly as possible in every instance I have heard of. It is his subordinates who consider they have the right to tamper with those whose goods they are employed to protect.

Would it cost a great deal for the shareholders in this large co-operative business to be allowed the privilege of a free admission for a friend? The co-operative principle is splendid, and the success is gratifying; but the profits? Well, they are given away by the directors, and the shareholders have the pleasure of—seeing the money go.—Yours, &c.,

July 29th, 1885. ANOTHER EXHIBITOR.

P.S.—Our electrical friends might surely help one another to light their stands properly if the authorities will not light up their circuits in an efficient manner. Let them take the hint.

AN AUTOMATIC RESPONDER.—An ingenious device has been patented in America which will add to the usefulness of the telephone. The invention, briefly, consists, in adding a simple apparatus to each subscriber's instrument, so that any one calling up a distant station, &c., is automatically notified whether there is any person present to receive his call and message. The advantages of this addition to the telephonic system are sufficiently obvious.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

VOLUME XIV.

Volume XIV. of "THE ELECTRICIAN," bound in cloth cover, price 10s. 6d, is now ready.

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THE INTERNATIONAL TELEGRAPH CONFERENCE.

When the propositions to be discussed by the Berlin Telegraph Conference have taken a more definite shape we shall have probably something very definite to say about at least one of them. But for the moment we will confine ourselves to the forecast of what is likely to happen disclosed at a friendly interview between the representatives of the English Cable Companies on the one hand, and the British merchants on the other, which took place in Broad-street on Wednesday last. It does not surprise us that the Chambers of Commerce were nervously anxious to learn how their interests are to be served at the Conference. Those interests are, it is well known, not exactly the interests of the Cable Companies; and every succeeding year adds fresh proofs that the basis on which the world's cable property was created is being gradually undermined, not merely by reckless competition, but by the economic selfishness of the commercial community.

No one could have imagined when these cable enterprises were set on foot that in a few years' time the system of codifying telegrams would have grown to the extent it has done, still less that it would go on increasing with every fresh reduction of the rates. But the companies have bravely borne up against their threefold enemies, competition, low rates, and codification, and have so far steadily resisted the temptation to propose any wholesale restriction on the use of Codes adverse to the interests of their customers. It was probably with feelings something like those of a guilty culprit that the Chambers of Commerce sought an interview with delegates of the companies prior to their departure for the Conference; and if public bodies are capable of the sentiment of gratitude, the London and Liverpool Chambers of Commerce ought to be grateful for another acquittal which apparently they did not expect, and which, in reality, nobody thinks they deserve. So far as the English Cable Companies are concerned no propositions opposed to the wishes of their Code-using clients will be made at the Conference.

In using the phrase economic selfishness as descriptive of the action of the merchants we do not mean it in any offensive sense. While the companies themselves, who are the only sufferers by a wholesale employment of Code telegrams, accept the situation philosophically, and on this point are evidently far more liberal in their policy than are the several Governmental administrations, it is not for us to cast reproaches on those who have simply availed themselves of the privileges which a word tariff inevitably affords and directly encourages. It would be impossible to prevent the employment of Code altogether, seeing that it finally rests with the sender to declare whether his message is in Code or not. But it cannot be denied that the system has been carried to an unlooked for and quite unwarranted extent—unwarranted, we mean, considering the lowness of the charges, which are by no means remunerative at present, and show very few signs of becoming so.

We think that the word tariff is primarily responsible for the coding system; and although perhaps the time has gone by for reconsidering that form of tariff, or for curtailing in any material degree the economic evasions to which it has given rise, still it is well to remember that there is a limit to the financial endurance of the great cable proprietors beyond which it will be impossible to presume without breaking down the cabling business irretrievably. This, of course, is out of the question; although such a result would be not altogether unwelcome to some at least of the merchants who are the cables' best customers. It is a significant fact—which the companies will probably not soon forget—that one of the commercial representatives at the interview on Wednesday stated that the merchants of England would subscribe a million pounds to sweep all the cables out of the seas. When language such as this is employed in the face of the men who have risked so much and gained so little by the enterprise for which the world at large will for ever hold them in the highest honour, we may be pardoned the use of the word selfishness as indicating the attitude with which they are confronted. The shareholders of cable property have experienced no mercy at the hands of those whom the Chambers of Commerce represent, and it is plain that none is to be expected.

This being so, it is desirable that the limits of codification should be more strictly defined, if not substantially curtailed. The barbarous and excruciating combinations into which the language is distorted for coding purposes is not merely vexatious to the operator, but a serious hindrance to the expeditious despatch of business. If senders could be brought to view the case in this light nothing further need be done in the way of regulation; but this is past hoping for, and the only amelioration at present practicable to which both parties

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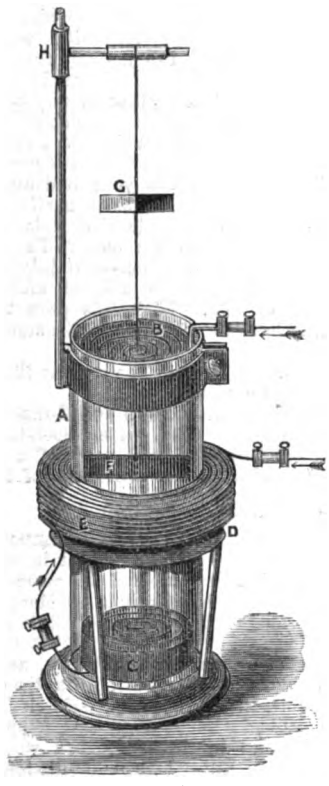
will assent is the adoption of a recognised vocabulary embracing every code word the companies are willing to accept. Difficult as the task of compilation would be, its completion would have the merit of finality, and finality in this relation is what the Cable Companies have a right to insist upon. They allege that the average length of the cablegram has been reduced by more than half under the Code system. And what makes matters still worse is, that the time occupied in signalling is, word for word, half as much again as it was formerly; and that consequently not only has the revenue been diminished, but the ability to deal with increased traffic, by which alone this loss of revenue can be made up, is lessened in a like proportion.

APPARATUS FOR SHOWING THE ELECTRO-MAGNETIC ROTATION OF ELECTROLYTES.*

BY DR. G. GORE, F.R.S.

This apparatus was devised and used for the purpose of investigating the influence of magnetism upon an electrolyte conveying a vertical electric current in the interior of a hollow and vertical electro-magnet.



Apparatus for Showing the Electro-Magnetic Rotation of Electrolytes.

A is a glass vessel 8in. high and 2in. diameter, nearly filled with an acidulated solution of cupric sulphate. B, a spiral ribbon of thin sheet copper ¼in. wide, wholly immersed in the liquid, and used as an anode by means of the connecting wire and binding screw attached to it. C, a similar spiral, used as a cathode, its connecting strip being passed through a hole in the side of the vessel and secured water-tight by means of sealing wax. D, an annular metal table with three legs, used to support a coil of wire. E, a coil of moderately stout insulated copper wire, about 2 or 3 inches in height. F, a perfectly flat vane of sheet copper, covered completely with varnish, and supported by a fine silk fibre. G, a vane of white cardboard, blackened on one half of each side, and attached to the fibre, in order to render manifest at a distance the rotation of the lower vane. H, a brass tube, supported by and sliding vertically upon a brass rod, I, and having upon its arm a closely-fitting tube of india rubber, used as a roller to which the silk fibre is attached, and by means of which the position of the lower vane is adjusted. For lecture purposes a much larger model of the apparatus is desirable.

With this apparatus and an electric current from two or three Grove cells passing through the liquid and the coil, rotation of certain portions of the liquid takes place. Opposite the central part of the coil, and at a point a short distance above the level of its upper end, and at another point at an equal distance below its lower end, no rotation of the liquid occurs. With a downward current in the liquid and a south pole at the upper end of the coil, as produced by the direction of current shown in the sketch, the liquid on a level with the top of the coil, and also that portion of it immediately below the lower neutral point, revolves in a dextro direction, whilst that on a level with the bottom end of the coil, and that portion immediately above the upper neutral point, moves in a laevo one. As a matter of course reversing the direction, either of the current in the coil or of that in the liquid, reverses the directions of rotation, whilst reversing the direction of current in both does not alter them.

Too strong a downward current in the liquid causes streams of light liquid, exhausted of metal, to rise from the lower electrode, and disturb the rotation of the vane, especially if the vane is not a perfectly flat one; and it is advisable to occasionally reverse the direction of the current in the solution. The apparatus is suitable for demonstrations of lectures.

* Read before the Birmingham Philosophical Society, June 11, 1885.

THE FORTHCOMING INTERNATIONAL TELEGRAPH CONFERENCE.

A Conference between the Representatives of the London and Liverpool Chambers of Commerce and the Delegates of the Submarine Cable Companies to the International Telegraph Conference, at Berlin, with reference to the propositions to be submitted to the Conference, took place at the office of the Eastern Telegraph Company on 29th inst. Mr. John Pender, M.P., Chairman of the Eastern Company, presided.

The CHAIRMAN stated that the Representatives of the different Cable Companies had been invited to meet Representatives of the Chambers of Commerce, who were desirous of offering some points for the consideration of the Delegates before the Conference took place. The companies were always desirous of giving their best attention to practical suggestions which would benefit their customers and themselves alike, but although the companies unitedly represented about £34,000,000 of capital and 100,000 miles of cables, against 7,000 miles of cable in the hands of the different Governments, they (the companies) had no vote at the Conference. The system was a most expensive one to maintain. They did not yet know what the life of a cable was, and the code system had pressed so hardly upon the companies that they could not possibly increase reserves or dividends. The object of the companies at the Conference was to prevent the existing arrangements between themselves and the public being interefered with; but they would at the same time ask that there should be an official dictionary or list of code words introduced which would settle the vexed question of what was and what was not a legitimate word. The directors of the companies were in the position of trustees, and had to earn a dividend for their shareholders as well as to maintain the system; but business had been cut so close by the merchants that the reduction could not continue or the companies would be obliged to ask for double tariffs for code messages. In his experience he had always found that the first consideration of the telegraph companies had been the public and how they could best serve them. In conclusion, Mr. Pender urged merchants when preparing codes to avoid those word combinations which took three times as long as ordinary words to transmit over the lines.

Mr. MURRAY, the secretary of the London Chamber of Commerce, read a letter from the Glasgow Chamber, setting forth the views of merchants there.

Mr. OGILVIE (Ogilvie, Gillanders and Co.) stated that the main thing Liverpool merchants wanted to know was, if there would be any further restrictions on code words which would involve a re-construction of existing codes and also a re-admission of proper and geographical names as one word whatever their length might be. The only other point he would refer to was as to the enclitic terminations "quo" "ve" "ne." It was a serious matter for merchants to have to pay double for such words.

Sir JAMES ANDERSON said if the codes were compiled according to the Convention rules, by which the companies were strictly bound, they would not have the trouble of altering their codes. The failure on the part of the companies to observe the rules might result in the forfeit of some of their concessions.

Mr. MACANDREW said previous changes made by International Convention had been in the direction of abridging the facilities enjoyed by the

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public. It was rumoured that the limit of ten words was to be reduced to eight, but that had been denied by the Cable Companies. It was currently reported also that the use of inflections, plurals, &c., would be forbidden, and if this were so all the existing codes would be rendered useless.

Mr. NEIL (of Neil Brothers) referred to the inconvenience of the limitation of European code messages to one language. This, however, it was explained, the companies had nothing to do with. Mr. Neil, continuing, said a suggestion had been made at the London Chamber of Commerce that the companies should agree upon a list of not less than 200,000 words which they would allow the use of in all codes.

Sir JAMES ANDERSON said there were only two things which the representatives of the companies were agreed to propose at the Conference. First that the charges for rectifying telegrams should be under the control of the terminal administrations, so that the charge for repetition need not necessarily be collected until the message was proved to have been correctly transmitted in the first instance. The only other proposition was that *bonâ fide* names of stations or places, such as Rio de Janeiro in the address of telegrams should, even if in excess of ten letters, be counted as one word. As to codes, a great grievance of the companies was that some of the manufactured words occupied the line three times as long as ordinary language, and that the carrying capacity of any cable was mainly the number of words they could transmit in the six or eight busy hours of the day; the difficult manufactured words now coming into use reduced the capacity of cables. He thought that if the Berne Bureau should compile an authorised dictionary of the languages available for code purposes, with such inflections as might be admissible according to the usage of the languages, the companies would be very glad to adopt it and take their chance.

Mr. ANDREWS (Indo-European Company) called attention to the Convention definition of code language, and said that in addition to the delay in transmitting manufactured words the companies really transmitted free about one-third the average number of words of every commercial telegram, but he thought that if a representative body like the Chamber of Commerce were in favour of an official code, all difficulties as to illegitimate words would be done away with, and pointed out that groups of letters which did not fall within the Convention definition of a word should really be taxed as cyphers, of which three are counted to a word. It was due to the intercession of the submarine companies that eight languages were allowed for extra European code messages, as the Conference wished to allow only four. It was the companies also who had introduced the word rate.

Mr. WEAVER (Anglo-American Company) said the code system had been the ruin of the American traffic, and personally he would like to do away with it altogether. In 1872 the average number of words in messages was 18½; it was now 8½. None of the Atlantic Companies were making any profit, whereas but for the Codes they would be paying large dividends.

Sir JAMES ANDERSON said the Eastern Company did 54 per cent. more work, and earned only 12¼ more gross revenue. The Direct Spanish transmitted 102 per cent. more telegrams and lost money. In one Code which had come under his notice one word represented 109 words, and a Bank circular of 49 words could be expressed in two.

Another gentleman defended the use of unfamiliar combinations, because telegraph clerks "jumped" the terminations of well known words, and so frequently made mistakes.

Another speaker expressed the satisfaction with which he had heard what the propositions of the companies to the Conference were, and thought they were rather in the direction of increased facilities than otherwise.

Sir JAMES ANDERSON then briefly mentioned the propositions of the various Government Telegraph Administrations at the approaching Conference as far as they affected merchants using Code language.

The CHAIRMAN said the companies were endeavouring to obtain a continuous line of telegraph to the far East under their own control, and merchants might render much assistance by exerting their influence in favour of it, as it would facilitate telegrams passing to and from China, Australia, &c. In conclusion, he begged to thank the gentlemen present for attending the meeting, and he thought the conversation which had taken place would do a great deal of good.

The meeting then separated.

THE SUBMARINE CABLES BILL.

[The lack of space prevents us doing more than give a full report of the discussion in the House of Lords upon the Submarine Cables Bill. In a subsequent issue we hope to give the Bill as amended.—ED. *E.*]

In the House of Lords last week, before this Bill went into Committee,

The Marquis of TWEEDDALE said: My Lords—Before this Bill is considered in Committee, I trust your lordships will allow me to occupy your time for a few moments. My object in addressing your lordships is to record my protest against the manner in which the Convention which your lordships will presently be asked to pass into law was obtained. The title of this Convention is a Convention for the Protection of Submarine Telegraph Cables. I think that it is right that I should tell your lordships the nature of the property affected by this Convention. That property consists of 110,000 miles of submarine telegraph cables, of which 98,000 miles belong to private individuals or to public companies. The whole of the 110,000 miles has been laid at different times by English hands, is maintained by English hands, and the greater part is repaired from time to time by English hands. The value of the property, as far as it belongs to private individuals and companies, is estimated at thirty-four millions sterling, and the owners of this property are for the greater part inhabitants of the United Kingdom. That, my lords, is the nature of the property to which this Convention applies, and for the protection of which this Convention was held in March, 1884. The Convention was composed in this way:—Representatives of twenty-six Powers, namely, the Powers of Europe, two Asiatic Powers (the Shah of Persia and the Indian Government), the United States, and some eight or ten smaller Governments in North and South America, Costa Rica, and others of that description. The only feature which was common to the representatives of these powers was complete ignorance of everything connected with submarine telegraphs. I do not believe that there was one person sitting on the Convention who had any knowledge, either theoretical or practical, of the laying or maintaining, or repairing of submarine telegraph cables. That being the case, your lordships would naturally expect that the Convention would have communicated in some way with the owners of the valuable property to which I have referred. But they did nothing of the kind. They proceeded to legislate for them in complete ignorance, and they neither invited nor consulted the only persons who were capable of giving an opinion of any value upon the subject. The result is exactly what might have been expected—namely, a Convention which contains some articles of value, but includes others so objectionable that the owners of this large property, almost to a man, have petitioned your lordships that this Bill, designed for their protection, shall not become law. A petition was presented by the noble and learned lord (Lord Bramwell) who is sitting near me, representing something like four millions of this property. I had the honour of presenting one to-day which represented about 23 millions of money—27 millions out of 34 millions. Both those petitions ask your lordships not to pass the Bill, notwithstanding the fact that it was designed for their protection. What they say in one word is this—that so far from its being calculated to protect them, it is eminently calculated to injure them, and in some instances to ruin them. Now, I think the best evidence I can give your lordships that this is not an exaggerated view of the Bill and its probable effects is furnished by the amendments which the noble duke, who has charge of the Bill, has placed upon the paper. They deal with two of the most objectionable clauses in the Bill. I do not say that they deal with them adequately, but they do deal with them in an important manner. One amendment is very useful, and the other is very practical. I have also proposed amendments on these clauses, which in my humble judgment are in some respects superior to those which the noble duke has placed on the paper. I believe that the owners of telegraph cables prefer my amendments, and I hope to persuade your lordships, when the proper time comes, to take the same view. I have merely risen to record this protest, for I think that it is intolerable that a large and valuable property should be dealt with, as was the case in Paris last March by the Convention, without any communication—certainly no official communication—with those who were to be affected, and for whose benefit the Convention was ostensibly held. With this protest I shall reserve the further remarks I may have to make until the amendments come before your lordships.

The House then went into Committee upon the Bill.

Clause 1 was put and agreed to.

On Clause 2, the Duke of RICHMOND and GORDON said: My Lords—The noble Marquis (Tweeddale) has got an amendment to Clause 2. In order to shorten the proceedings I will accept Clause 2 with the words added on line 9, "Subject to the provisions of this Act." I see no objection to this.

Clause 2 was put as amended and agreed to.

On Clause 3, the Duke of RICHMOND and GORDON said: My Lords—With reference to the amendments which stand in my name in Clause 3, page 3, after sub-section 3, I have adopted this amendment in consequence of a representation which was made by the noble Marquis (Tweeddale) in an interview which I had with him and some other gentlemen who were interested in this subject. They pointed out that the clause in the Bill might affect the telegraph companies injuriously, and render them liable to be punished by a fine or imprisonment, if, in the exercise of their duty of mending their cable, they injure somebody else's cable; because, in mending their own cable, it might very well happen that they might damage another cable, and by so doing they would bring themselves within the purview of this Bill. I thought, therefore, that it would be right to consider the points raised by the noble marquis (Tweeddale), because I confess I felt there was some force in them, and therefore I have proposed an amendment which will run in the following words:—"A person shall not be deemed to have acted wilfully who, in order to the repair of one submarine cable, is unavoidably compelled, by reason of not being able to effect the repair otherwise, to break or injure another submarine cable; but this provision shall not apply so as to exempt such person from any liability to pay the cost of repairing such breakage or injury." And, therefore, when in the honest and necessary mending of his own cable, the owner of the cable damages another, he shall not be considered to have acted wilfully in that transaction; and it seems to me that those words will cover all that is desired, and protect the companies from what might otherwise, unless there had been an amendment, have been an injury to them. I am not quite sure that they would have fallen under the clause, but still I thought it better to explain it by those words, which certainly enable a person to repair his own cable without the risk of being sent to gaol for any mistake he might make in repairing his own. I beg to move that those words be inserted.

The Marquis of TWEEDDALE: My lords, I am anxious to state the objections I have to this amendment, the principle of which I agree with. The objects of the noble duke's amendment, and of mine, are to prevent the punishment of an entirely innocent man. In the Act, as it stands now, the captain of a ship may injure another cable, and thus render himself liable to punishment—fine or imprisonment. What I object to in this amendment is the ambiguous word "unavoidably." It would be almost

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impossible to invent a word more unsuited to the kind of operations which take place in mid-ocean for the repair of a cable than the word "unavoidably." What is wanted is not that a particular act done by a captain in the way of repairing a cable where there are several cables lying, perhaps three miles deep, at the bottom of the sea is unavoidable or not. What we want to know is whether the ship is properly found; whether everything has been done to ensure the complete success of any particular expedition; whether the proper captain—the best man to be found for the work—was employed; whether the scientific persons accompanying the expedition were well instructed. Questions like those are of the greatest importance, and are easily investigated, but it would be almost impossible to arrive at any opinion as to whether any particular act performed by a captain of a ship was avoidable or unavoidable. It is obvious that in some cases, such as where one cable is overlying another, it would be impossible to repair the one without injuring the other, and such an act would be unavoidable in the strictest sense of the word. But this is a very simple problem compared with many which have to be dealt with. For instance, take the case of two cables lying, say, 10 miles apart. Supposing one of them has to be taken up, say A, and that the captain of the ship going out, with a perfectly honest intention of repairing cable A, by an accident of a kind which has occurred repeatedly in the Atlantic, grappled and injured cable B, lying 10 miles away—you cannot say that this was unavoidable. It was unintentional, but certainly not unavoidable, inasmuch as if the grappling irons had been dropped at a distance of nine miles all injury to the cable would be avoided. Whether this is so or not I cannot conceive a term which would be more calculated to puzzle people more than this word "unavoidable." The amendment I have put on the paper is this:—"Where a person does any act with the object of repairing a submarine cable, and takes all reasonable precautions to avoid injury to any other submarine cable, such person shall not be deemed to have acted unlawfully and wilfully within the meaning of this section." What is required by this amendment is that on a repairing expedition dealing with cables every reasonable precaution to avoid doing any injury to another cable is to be taken. That appears to me to be based on a sound principle. I believe that it is entirely consistent with English law, as it stands at present—certainly as the law has been interpreted by the department over which the noble duke presides. The Board of Trade, in a letter which they addressed to the chairman of one of the cable companies, dated 1st of July, 1882, with reference to this very question, whether protection could be extended to telegraph cables, made this answer:—"The Board of Trade have been informed by several other telegraph companies that the utmost measure of protection which they desire is to be protected from wilful and wanton or careless injury. The wishes of those companies seem to be practically satisfied by the English law as it at present stands. It appears to have been determined, both at common law and in the Admiralty Court, that a vessel, whether English or foreign, is bound, in dealing with a telegraph cable, to exercise ordinary skill and care, and that if either within British limits or beyond them a vessel does injury to a telegraph cable, which by the exercise of ordinary skill and care she might have avoided doing, she is liable in damages to the owners of the cable." That is to say, if ordinary skill and care and all reasonable precautions are taken the captain would not be liable for damages; and the authorities are given in the next paragraph. Then it goes on with regard to the jurisdiction:—"It appears also that any malicious injury to a telegraph cable committed within British jurisdiction or committed elsewhere by a British subject or a British vessel can be punished criminally in this country under the Malicious Injuries Act, and under the Merchant Shipping Act, 1852, sec. 267." Therefore, the effect of this letter addressed to the cable companies in 1882 was practically that the law provided all that was necessary for their protection. Now, this was assumed by the companies, and made them much less alert when the Paris Convention was sitting, because they felt that the law perfectly equitably and reasonally provided for the cases which they had submitted to the Board of Trade. The amendment now proposed is based upon the law as interpreted by the Board of Trade. It simply says that a company or an individual, if he undertakes to lay or repair a cable must, if he wants to avoid either civil damages or a criminal prosecution, take all reasonable precautions in carrying out the business which he has undertaken. For these reasons I venture to think that my amendment is, with all due deference to the noble duke, superior to the one that he has proposed. It is one which is approved of by the telegraph cable companies, and I think it will approve itself to your lordships.

The following is a copy of the amendment proposed by the Marquis of Tweeddale:—"Where a person does any act with the object of repairing a submarine cable and takes all reasonable precautions to avoid injury to any other submarine cable, such person shall not be deemed to have acted unlawfully and wilfully within the meaning of this section."

Lord BRAMWELL: My lords, as I presented the petition which has been alluded to by the noble marquis, I have now to make some observations on behalf of those whom I represent with reference to this particular clause. They come here with no ungrateful feelings towards this Convention. They think it a very useful one, and they are also grateful for this Bill which is to give force to it; but they certainly do feel, as the noble marquis says, that it would have been better if some experienced person in these matters had been consulted by them, and I cannot help thinking that this is a very dangerous piece of legislation. Now, my lords, the clause as it originally stood was undoubtedly open to the strictures mentioned by the noble duke. It seems to me that the amendment is an improvement upon it, and with great submission I think that the amendment of the noble marquis is an improvement on the amendment of the noble duke's; but still I am not satisfied with that, and I shall propose a third amendment to your lordships. The objection I have to the amendment of the noble duke is that in the first place it says that it shall not be deemed wilful to do that which is wilful—that is to say, if you can avoid it, and do it, it will be wilful, and, therefore, it is objectionable to say that shall not be deemed wilful which is not wilful. There is another objection to that word "unavoidable." Just consider what questions will be raised. It will be said that it was avoidable, you need not have done it, and you might have done it without causing the injury. Supposing this goes before a jury or any other tribunal—you say this man shall suffer five years' penal servitude though it was done perfectly *bonâ fide* and he did his best, but that he was not skilful enough or he might have avoided breaking the cable. Those are the objections to the amendment of the noble duke. I think that the objection to the amendment of the noble marquis is this. He says: "Where "a person does any act for the purpose of repairing a submarine cable, "and takes all reasonable precautions to avoid injury to another sub-"marine cable, such person shall not be deemed to have acted criminally." There the same difficulty almost arises. You did take all reasonable precautions to avoid injury, and you acted perfectly honest and *bonâ fide*, that you may have done; but if you had understood your business better you would have done otherwise, and therefore you suffer five years' penal servitude. It is not the intention of the noble duke, and it is not the intention of the noble marquis, that it should be so. Now, let us consider what your lordships have in view. What you have in view is to punish persons who, by culpable negligence or wilfulness, damage a submarine cable. That is the object you have in view. Consistently with that it is the intention, I am sure, of the noble duke, from the language that he has used, that people may, in attempting to get at their cable and repair their own cable, injure the cable of another company without committing a crime. It is not intended that they should commit a crime or run the risk of committing a crime if they, *bonâ fide* attempting to get their own cable, do some mischief to some other cable. That is the general intention, and I therefore respectfully submit to your lordships, and I thank the noble duke for the concessions he has granted and his good intentions towards the Cable Companies, and I think that this would be properly provided for by stating: "This section shall not extend to any case where, in the *bonâ fide* attempt to repair a submarine cable, injury has been caused to another cable, or the same has been broken; but this shall not apply so as to prevent their being liable civilly." Now, that seems a preferable amendment—if the noble duke will allow me to say so—to his, and a preferable amendment to that of the noble marquis, and I suggest it to your lordships. I am sorry to say that I did not give notice of it, as it was only recently that it was brought to my attention.

The Duke of RICHMOND and GORDON (to Lord Bramwell): Read it again.

Lord BRAMWELL: "This section shall not extend to any case where, in the *bonâ fide* attempt to repair a submarine cable, injury has been caused to another cable, or the same has been broken; but this shall not apply so as to prevent civil liability."

The Duke of RICHMOND and GORDON: My lords, I am under a very great disadvantage, because the noble and learned lord has brought forward an amendment of which I had not the smallest idea until the present moment.

Lord BRAMWELL: I am sorry to say that is so.

The Duke of RICHMOND and GORDON: And therefore I have not been able to give it all that attention which I ought. With regard to some of the remarks which the noble marquis made as to preferring his new amendment to mine, I must say that he is a very recent convert to the words which he has proposed in the amendment now under discussion, and proposed by him, because I am sure he will admit I am stating that which is a fact when I say that the amendment which I have proposed is his amendment, but amended by the insertion of one or two words; and therefore I was rather astonished to hear the noble marquis expatiate on the merits of his own amendment and on the demerits of mine, when, practically, I really adopted his amendment, and put in one or two words of my own. The noble marquis also referred to the difficulties of repairing cables in the Atlantic, but I think that the noble marquis will forgive me for saying that the amendment which I propose to insert in the Bill defines this to be within the 100-fathom limit, and therefore all that the noble marquis told us of the operation of this Bill in the Atlantic, he will forgive me for saying so, was not very much to the purpose, because my amendment confines it to within the 100-fathom limit. We all have the same object, I believe, and that is mending the clause so as to satisfy the parties that they will suffer no injury in the execution of what is their legitimate duty—that is to say, mending their cables. There are now three propositions before the Committee. There is the one which I proposed, and there is a second which is proposed by the noble marquis, and the third which is just now proposed by the noble and learned lord. I think that we have the same object in view. We seek by different roads to arrive at that object, but we all want the same common end. I do put my view of the case that my clause is better than that of the noble marquis. I will not put my legal experience in competition with that of the noble and learned lord opposite (Bramwell). His words may be better than mine, and I think that they are far better than those of the noble marquis, and therefore I take the liberty of suggesting to the noble and learned lord that if he would be good enough to print them, and bring them up on report, which I hope your lordships will be inclined to do to-morrow, I shall be able to see the words; and I can assure him that, if possible, I shall be prepared to accept those words unless they have a contrary effect to that which I believe at the present moment they have.

The LORD CHANCELLOR: My lords, I beg to call the attention of the noble and learned lord that we ought to see his words in print so that we may consider them on the report; but I must say that no form of language will get rid of a difficulty. In fact if a person is convicted of crime because he does something either negligently or wilfully, and if the question of negligence or wilfulness is to be determined upon the verdict of a jury, no form of words we can adopt in this House can avoid being remitted to the proper tribunal for discussion. I think that the word

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"unavoidable," and the words "*bonâ fide*," and the words "reasonable "care," are all of them open to the same ambiguity that a jury will have ultimately to determine, and it appears to me that some course should be adopted by which ambiguity could be avoided as to what is an act of will, and in that sense wilful, as in the case put by the noble marquis, where a person intends to cut a cable in two because he cannot otherwise get at the cable which he means to mend. But that is not intended to be an unlawful act, and it is not negligent because he intends to do it. It is, in a sense, of his will, and in that sense wilful, and the problem is to show that which ought to be criminal is criminal, and that which is only negligent should be only negligent, at the same time time reserving the civil liability. I thought that the amendment of the noble and learned lord met that better than the other two, and I think that the only question is as to whether the clause of the noble and learned lord will be able to give the intention more accurately, and endeavour to avoid the difficulties I have pointed out, and I should advise my noble friend to accept the amendment.

The Marquis of TWEEDDALE: My lords, I merely rise to say that I do not quite understand the force of the noble duke's criticism in what he said that some of my remarks were not to the point, because his (the noble duke's) amendment confined the operation of the clause to within the 100-fathom limit. The amendment has nothing to do with the 100-fathom limit, which applies solely to Article 4 of the Convention dealing with civil remedy for damage.

The clause was then agreed to *pro formâ* to admit of Lord Bramwell's amendment being considered on report. A new Clause 3 was proposed by the Marquis of Tweeddale, viz. :—"Article IV. of the Convention shall apply only to cables laid after this Act shall have come into force; but nothing in the Convention or this Act shall take away, prejudice, or affect any right or remedy to which by law any party is or may be entitled otherwise than under the provisions of the Convention or this Act."

The Duke of RICHMOND and GORDON said: My lords, I propose to accept part of this. This amendment, or rather this new clause, is proposed to be inserted after Clause 3, and is intended to meet the objections which have been raised by various parties interested in those cables, and where they complain that the scope of this measure goes far beyond that which was reasonable that it should do; and it would be very difficult indeed in mid-ocean to take up the cables, especially in some parts of the ocean where they cross over and where they are placed in close proximity to one another; and it would be almost impossible to deal with them in a manner which would be satisfactory. After consideration of the subject, and after consulting with some of those who I thought could give me good advice upon the subject; and after hearing what the noble marquis and his friends said on the occasion when they came to the Board of Trade, it occurred to me that it would be better that Article 4 under the schedule of this Act should only apply do a depth of water not exceeding 100 fathoms, because I am told that within the 100-fathom limit—which is so well defined in all the charts that there is no difficulty in finding it, and there is no difficulty in dealing with the cables within that depth of water—that it is, comparatively speaking, very easy to pick up and repair cables within the 100-fathom limit; and therefore I propose to meet the objection which the noble marquis made by proposing this "Article 4 of the schedule in this Act shall not apply to that part of the cable which is laid in a depth of water exceeding 100 fathoms." And then I propose to take the last part of the noble marquis's amendment in the same article, and insert these words:—"But nothing in the Convention or this Act shall take away, prejudice, or affect any right or remedy to which by law any party is or may be entitled otherwise than under the provisions of the Convention or this Act." I believe and I hope that it will meet the objections of the noble marquis, and I shall ask your lordships to insert this clause in the Bill.

The following is a copy of the amendment as agreed to (to be Clause 4 of the amended Bill):—

4. Article 4 of the schedule to this Act shall not apply to that part of a cable which is laid in a depth of water exceeding one hundred fathoms, but nothing in the Convention or this Act shall take away, prejudice, or affect any right or remedy to which by law any party is or may be entitled otherwise than under the provisions of the Convention or this Act.

The Marquis of TWEEDDALE: My Lords, I am very much obliged to the noble duke for the manner in which he has endeavoured to meet the wishes of those who object to this clause in the Convention. I have only to say that I accept the amendment.

The Earl of CAMPERDOWN: My Lords, may I ask the noble duke whether it is possible with reference to the terms of the Convention itself to make these alterations? The first article says:—"The present Convention applies outside territorial waters to all legally established submarine cables landed on the territories, colonies, or possessions of one or more of the High Contracting Parties." Now you are going to limit the Bill, which has to become an Act of Parliament—you are going to limit the application of this Act of Parliament to a certain set of cables. The Convention is to apply to all cables.

The Duke of RICHMOND and GORDON: The answer to that is that you cannot make Parliament do other than that which it chooses, and all that this country has done is to recommend the Convention and the contents of this Bill to the Legislature, and the Legislature is at liberty to deal with that Bill as it thinks fit. If it is not in the mind of Parliament to carry the whole of the Convention, we cannot insist upon this being done.

The Earl of CAMPERDOWN: "The high contracting parties" necessarily implies that we are parties to this Convention, and that we are to bring in measures for carrying the Convention into effect. Article 3 says:—"The High Contracting Parties undertake that, on granting a concession for landing a submarine cable, they will insist, so far as possible, upon proper measures of safety being taken, both as regards the track of the cable and its dimensions"—that is to say any submarine cable. My reason for asking this question is this, that I am very much afraid that we are going to establish a very excellent and thorough method for the punishment of British subjects. But what is passing through my mind is that the most dangerous time for a nation is when it is at war, and the case when a nation is at war is especially barred by this Convention. But this is a very dangerous moment, for it is just the time when operations dealt with by this Bill are likely to be undertaken by Submarine Cable Companies. And suppose there are other foreign nations who have not passed through their Legislatures measures which will punish adequately their subjects engaged in these operations, the result will be that English subjects will be punished thoroughly, because of course this law will be applied, and fairly and justly, in the English tribunals. And how do we know that foreign subjects who are engaged in that way will be punished at all? This is a limitation of the Convention.

Clause 3A, as amended, was put, and agreed to. Clauses 4, 5, 6, 7 and 8 were severally put and agreed to.

The Earl of REDESDALE: You wish to insert a new clause after Clause 8?

The Marquis of TWEEDDALE: Yes.

The Earl of REDESDALE: Leaving Clause 8 in?

The Marquis of TWEEDDALE: Yes. This clause which I have to submit to your lordships' approval is connected with Article 3 of the Convention, a very important article. My amendment is proposed in order that this article shall have effect given to it. The article is this:—"The High Contracting Parties undertake that, on granting a concession for landing a submarine cable, they will insist, so far as possible, upon proper measures of safety being taken, both as regards the track of the cable and its dimensions." Now, the object of this amendment is to secure in the future that a cable shall be laid in such a way that it shall not cause any injury to any other cable or lead to any injury. This is a very desirable thing. If this precaution had been taken earlier none of the difficulties, or scarcely any of the difficulties, which have arisen in connection with submarine cables would have taken place. Now, my lords, what I propose is that before any future concession becomes valid, it shall be treated as a provisional order. That is the principle of the amendment. In other words, that this concession shall be laid on the table of your lordships' House for a certain number of days, so that it may be examined and discussed, and, if necessary, objected to. Now, my lords, at present there is no machinery whatever for ascertaining the nature of a concession. A concession may be granted by the Board of Trade or by the Post Office, and nobody can see or know the terms of that concession. I do think that a concession should not be given to any person which has not been published to the world, and subjected to such criticism and inquiries as should enable any person who has any objection to it to lodge his objection. It is not necessary to read the amendment to your lordships. The question I submit is a question of principle, whether it is or not desirable to have concessions before they are granted laid upon the table of your lordships' House in order that they may be examined and objection taken to them and investigated if necessary. I beg to move that amendment to your lordships.

The amendment is as follows:—

"With respect to concessions to be hereafter granted of the right of landing submarine cables on the shores of the United Kingdom, the following enactments shall have effect:—1. No such concession shall be granted unless public notice of the application for and purport of the proposed concession has been previously given by advertisement once in the *London Gazette*, and twice in two successive weeks in two daily morning newspapers published in London. 2. Before any such concession be granted, the Board of Trade shall consider any objections which may be made thereto by any company or persons affected thereby, and of which notice in writing shall be given to the Board of Trade within 21 days after the date of the insertion in the *London Gazette* of the advertisement mentioned in this section. 3. A copy or statement of the material provisions of every such concession shall be inserted in the *London Gazette* within 14 days from the date thereof, and copies shall be laid before both Houses of Parliament within the like period if Parliament be then sitting, and if not, then within 14 days from the next sitting thereof."

The Duke of RICHMOND and GORDON: My lords—I have the strongest objection to this clause proposed by the noble marquis. In the first place the noble marquis talks about the concession, that it should be placed on the table of this House as a provisional order before it is granted.

The Marquis of TWEEDDALE: Before it is valid.

The Duke of RICHMOND and GORDON: It seems to me that the object of this clause proposed by the noble marquis is very much in favour of the existing companies, because if this clause proposed by the noble marquis was to take effect it would be very difficult for a new company to be established, because means might be taken during the time that they were making the application for the old companies to come and endeavour to buy up that which was proposed to be started. But I think that the noble marquis must have forgotten that the concessions which are granted by the Board of Trade are only concessions on the foreshore that is under their jurisdiction. There are other parties who have the right of making concessions. There are the Commissioners of Woods and Forests; there is the Duchy of Cornwall, where several cables are laid; there is the Duchy of Lancaster, and there are corporations who have the right, and also the Crown. And it would be a great hardship to any one to whom the foreshore belongs that he should not be able to grant a concession to a cable company to land on his own property without coming to Parliament and having it treated as a provisional order. Now, the noble marquis said that he proposed this clause also on the ground of safety, and that cables should not be laid in an improper manner. My lords, I believe it is the practice at the present time at the Post Office to give notice when they are laying down cables such as the noble marquis has alluded to—to give notice to cable companies in the vicinity of which the new cable is proposed to go, in order that they may be informed as to what is about to be done. And therefore I say that in the existing practice of the Post Office there is

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sufficient to carry out what the noble marquis proposes. And in the next place, I say that it is a very hard thing to compel persons who have the right to grant concessions to come to Parliament to ask Parliament to do that which they are enabled to do themselves; and therefore it is that I must offer my opposition to the proposal of the noble marquis.

Lord BRAMWELL: My lords, I beg to say a word in support of the noble marquis's proposition. There is difficulty in doing it I do not deny, but I should doubt very much whether any one would lay down a cable merely because he has got the permission of the owner of the foreshore. There will be some question as to the three mile limit. I do not want to trouble your lordships with the discussion of the matter where thirteen judges differed, in 1876, on this question; but I should doubt whether any one would be safe in laying down a cable merely because he got permission of the owner of the foreshore. I may say that I almost suggested this amendment to the noble marquis. The difficulty is this—here is an existing cable, another being proposed to start from a point near it, and either wilfully or not knowing where the first cable lies, perhaps it crosses it at a short distance from the shore, when they might just as well have started from some other point, and it would be a desirable thing that they should do so. Now, if some tribunal could decide as to the reasonableness of the starting point chosen, it would be an advantage. That was my object in making the suggestion.

The Marquis of TWEEDDALE: My lords, I beg to say that this is the only amendment which is not in any way inspired by the telegraph cable companies. I have had no communication from any of them on the subject, and there is no intention on my part of stopping other parties from getting concessions. One other observation I have to make. What I referred to was a concession made by the Government—not to a concession by private individuals. Article IV. of the Convention says:—"The High Contracting Parties undertake on granting a concession"—by the word "concession" I meant a Government concession; and I shall be happy to introduce words making this clear should the noble duke be willing to approve the principle of the amendment. With regard to the statement which the noble duke has made referring to the manner in which the Post Office gives notice, in cases of new concessions, and the expression of his opinion that such notice is sufficient, I beg to point out to the noble duke that the telegraph cables which have crossed other cables in the Atlantic more than any other of recent times were the cables last laid, and regarding which that very notice was given. The security afforded by the notice referred to by the noble duke is therefore, or at any rate has proved hitherto, altogether illusory. If this amendment is not adopted Article 3 of the Convention will remain for ever a dead letter. The amendment is proposed entirely in the interests of the public, for I believe that the public have a great interest in submarine telegraph concessions—that they should contain no conditions but such as are for the general benefit of the community. It is in the public interest that I ask your lordships to declare that in future the conditions of concessions shall be made known before they beome valid, and I shall ask your lordships' opinion upon the amendment. Clause 8A was then put and rejected without a division. On Clause 9—

Lord BRAMWELL said: My Lords, I wish to make a suggestion to the noble duke. By Article 4 of the Convention the owner of a cable who breaks or injures another cable will "bear the cost of repairing the breakage or injury, without projudice to the application, if need be, of Article 2 of the present Convention." Now, it appears that those who are interested in this matter think that this is really a very unjust provision; in this way—there are, I believe, two cables now which go to America, which can be used, but which are really worn out, and there are other cables that are not repairable. The only thing that can be done if they were broken would be to substitute a new one, and this article almost imposes an impossibility on those who may be so unfortunate as to break such a cable as that. They cannot grapple it up and repair it, but they can substitute another. That would not be repairing; but in the next place it would be substituting new for old without a reasonable allowance being made. If the noble duke thinks it worthy of his attention I shall be glad to amend that.

The Duke of RICHMOND and GORDON was understood to say that he would take it into consideration.

The Bill as amended was then passed through Committee of the whole House, and ordered to be reported.

On Friday, July 24, the subject was resumed.

The Duke of RICHMOND and GORDON: My Lords, I have had an amendment submitted to me by Lord Bramwell, and it has just been laid on the table of the House, and with the consent of the noble lord I will read it. On Clause 2, page 3, after Sub-section 3, to insert as a new subsection, strike out in the printed copy of the amendment the words "provided that," and let it run, "A person shall not be deemed to have unlawfully and wilfully broken or injured any submarine cable where, in the *bonâ fide* attempt to repair another submarine cable, injury has been done to such first-mentioned cable, or the same has been broken; but this shall not apply so as to exempt such person from any liability under this Act or otherwise to pay the cost of repairing such breakage or injury."

The amendment was then formally put and agreed to.

The Earl of CAMPERDOWN: My Lords, on the motion for receiving the report I wish to ask a question on a point which requires explanation. I tried to do so yesterday, but on that occasion I was not so fortunate as to obtain an answer. I must remind your lordships that this Bill is brought in for the purpose of putting in force and for making regulations on behalf of the English Government to carry out the terms of the Convention. The Convention itself does not come under discussion, and I do not quite understand how the Committee yesterday were justified in inserting a new clause which appears to be a limitation of Article No. 4. The Government of the Queen undertook to take the whole of the necessary measures in order to carry out the terms of that Convention; but this clause proposes to limit one portion of it, and I do not see how it is consistent with the duty of the Government that that is done.

The Duke of RICHMOND and GORDON: My Lords, the Government has to submit a Bill embodying the recommendations of the Convention to Parliament, and that of course must be dealt with according to the wishes of Parliament. The Government cannot undertake to carry through the Convention entirely, they can only get that part of it which Parliament will sanction.

The Earl of CAMPERDOWN: The noble duke and his colleagues have not gone so far as they might to carry out the Convention. Parliament has refused nothing; but the noble duke has imposed a limitation and not Parliament.

The Earl of SELBORNE made some inaudible remarks.

The Marquis of SALISBURY, who was very indistinctly heard, was understood to say that the Government took the course which appeared to them reasonable, and gave Parliament the opportunity of confirming the Convention, and the Bill covered those parts of the Convention which were essential.

The Earl of CAMPERDOWN: My Lords—The noble marquis seems to forget that the other Governments may make different arrangements, and the result may be that may say "You are not carrying out the terms of the Convention, and then we on our part will not do so."

The Bill was ordered to be reported to the House as amended.

It was read a third time and passed, with the amendments, on the 27th inst., and sent to the House of Commons for approval of the amendments.

LEGAL.

In Re Edwards's Trade Mark.

In the High Court of Justice, Chancery Division (before Vice-Chancellor Bacon), on Wednesday a summons by Messrs. Felten, Guilleaume and Co., asking that the Register of Trade Marks might be rectified limiting the trade mark No. 14,288, the property of Mr. T. E. Edwards, to unwrought and partly-wrought metals, used in manufacture, other than steel and iron wire, came on for hearing. In 1883 Mr. Edwards took an assignment of trade mark 14,288 from Messrs. Cromar, Scott, and Co., of Liverpool, who, in 1878, registered their "Neptune Iron" and "Neptune Brand," in respect of all goods in Class 5. On the 20th of March, 1880, Messrs. Felten, Guilleaume and Co., of Mulheim, near Cologne, registered trade mark No. 22,141, in respect of "steel wire and iron wire," in Class 5. Edwards's trade marks had a figure of the god Neptune with a dolphin's tail in the sea and carrying a trident. Felten's trade mark was the head of a trident with the letters "F.G." on each side and the word "Neptune" underneath. In 1884 Mr. Justice A. L. Smith granted an injunction restraining Mr. W. F. Dennis, the London agent of Messrs. Felten, Guilleaume and Co., from using their Neptune trade-mark on steel or iron wire. In April last an application was heard before the Vice-Chancellor on behalf of Mr. Edwards, asking that Messrs. Felten, Guilleaume and Co.'s trade mark might be struck off the register, and his lordship reserved judgment pending an appeal from the judgment of Mr. Justice A. L. Smith.

Mr. ASTON, Q.C., and Mr. JOHN CUTLER, for Messrs. Felten, Guilleaume and Co., contended that though Mr. Edwards's mark had been registered for five years it never had been registered in respect of the particular class of goods manufactured by the applicants—namely, steel and iron wire.

Mr. HEMMING, Q.C., and Mr. P. OGDEN LAWRENCE, for Mr. Edwards, urged that his trade mark having been on the register for five years was conclusive; but, as a matter of fact, the registration, apart from Section 3 of the Trade Marks Acts, 1875, was good.

The VICE-CHANCELLOR said that Messrs. Cromar, Scott and Co. never did manufacture steel and iron wire, and, therefore, never assigned any goodwill of that manufacture to Mr. Edwards. Mr. Edwards, therefore, had no right to prevent Messrs. Felten, Guilleaume and Co. from using their trade mark to these goods. But then it was argued that the Court had no jurisdiction to alter the register after the expiration of five years. His lordship had no doubt of the right of the Court to rectify the register after five years in proper cases, and made the order in the terms of the summons, reserving the question of costs.

COMPANIES' MEETINGS & REPORTS.

The Direct United States Cable Company (Limited).

The sixteenth ordinary general meeting of this Company was held at the Cannon-street Hotel, London, E.C., on Friday, the 24th inst., under the presidency of Mr. John Pender, M.P.

The SECRETARY and TRAFFIC MANAGER (Mr. J. W. Fuller) having read the notice convening the meeting, the Directors' report and statement of accounts were taken as read.

The CHAIRMAN then said: Gentlemen, the revenue for the half year to 30th June, after deducting out payments, amounted to £36,106. 1s. 1d., and the working expenses, income-tax, and other payments (exclusive of cost of repairs) absorb £17,206. 15s. 11d., leaving a balance of £18,899. 5s. 2d. as the net profit of the half year, making with £17,251. 2s. 11d. brought from the previous half year, a total of £36,150. 8s. 1d., which has been appropriated as follows:—Interim dividend of 3s. per share to 31st March, £9,106. 10s.; proposed final dividend of 3s. per share to 30th June, £9,106. 10s.; transferred to reserve fund,

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£7,203. 13s. 6d. ; balance carried forward £10,733. 14s. 7d.—total, £36,150. 8s. 1d. The revenue shows a decrease of £32,467 as compared with the corresponding period of last year, owing to the operation of the reduced tariff, to competition, and to the continuation of that general commercial depression from which our business has suffered for a considerable time past. The expenses in London are slightly higher, while those at the stations are lower than in 1884. It will be observed from the details given in the accounts that this reduction in the stations' total expenditure has been effected in spite of a considerable and unavoidable increase in the item of printing and stationery. We have incurred special outlay on law account during the past half year, but the matters in question were finally settled prior to the 30th of June. With the exception of income-tax (increased by the 8d. rate), the remaining items of expenditure are practically unaltered. The reserve fund, after being charged with £2,858 for cost of repairs, now amounts to £310.000. The Company's investments amount to £304,921. 4s. 1d. The present market value of the securities is in excess of their cost to the Company. When I had the pleasure of addressing you at the last half-yearly meeting I made what I then believed would prove to be a correct statement as to the probable result of the competition upon which we were then entering. I stated that the reduction of the rate from 2s. to 1s. 8d. would involve a loss of at least £150,000 a year. That statement has been fully confirmed, and more than this, there has been no corresponding increase of traffic to recoup that loss ; the depressed state of trade in America has still further tended to reduce the gross traffic, so that during the six months the traffic and returns have steadily declined. I then also mentioned that the two new cables introduced by Messrs. Mackay and Bennett were entirely superfluous, and those cables have done nothing to create new traffic, but have simply taken away a portion of the current earnings, which have been lessened by their hasty and ill-advised reduction. During the last six months the companies working in concert with us have all had their cables interrupted more or less—in fact we have had to work at different periods with six, five, and four cables respectively, instead of with eight cables ; therefore the proportion going to the two new cables might appear to the proprietors of those cables more satisfactory than it really is, because had we been working with all our cables their receipts would have been proportionately less ; but even as it is their earnings have probably amounted to about 28 per cent. of the receipts. With such a return they cannot possibly be satisfied. One of the Western Union cables and that of the French Company are still broken ; but no doubt they will be very shortly repaired during the fine weather, so that a reduction of the Mackay-Bennett proportion must follow, and I think I may say without much hesitation that when all our cables are at work it is not likely their proportion will reach 16 per cent. Now, the figures which I have quoted justify me in making the remarks which I am now going to do, viz., that when I last addressed you I told you you must be prepared to look a reduced dividend in the face. That reduced dividend, I am sorry to say, has come about. We are, therefore, now in the position of either having a higher rate or being obliged for a time to make a considerably lower one, because to work at the present tariff, with no immediate prospect of any increase in the traffic, we consider, as men of business, would be unwise. I am, however, hopeful that when those interested in the Mackay-Bennett venture find that the business is such an unsatisfactory one we cannot conceive that they will not be anxious to come to some understanding which will increase their earnings. I have always stated that very low rates must bring about a reduction, and that if the public reap the benefit of them at one time they must pay for them at another, and considering the precarious nature of the property, and the large amount of money invested in it, and that Atlantic telegraphy has now become a public necessity, we think we are entitled to such rates as will give a fair return, and your Directors are prepared to take every step possible to bring about such a result. At the present moment there is a very serious—I might almost say a very disastrous—competition going on between the telegraph land lines in America. The Western Union, as you know, was the pioneer company, and the company which has opened up America in a marvellous way by its telegraph system. As I have before stated, there is no place in the whole of the United States of even secondary or tertiary importance where this system is not to be found ; and you will remember that at one of our meetings I mentioned the fact that even on the frontiers of the Indian Reservations I found the Western Union Company established. The Western Union Company has no doubt absorbed during the last few years a considerable number of minor companies which were established to compete with it. This business of building lines to be sold was for a time supposed to be a very profitable one to those who built them, but during the last two or three years the reverse has been the case, and several companies that have been established have gone into liquidation. Mr. Mackay has associated himself with one or two land line companies with a view to collect traffic for his submarine system. I believe that the whole of the land line system in America at the present moment is so unsatisfactory owing to competition that the probability is that before a permanent settlement of the submarine system can be made there must be some arrangement come to by those land line companies, and looking to the fact that those companies are now carrying traffic at rates which are likely to materially reduce their dividends, and in all probability to cause the younger companies to give no dividend at all, and considering that Americans are as a rule shrewd men of business, I hope that this will only go on for a short time. The land line question being settled, then the probability is that the submarine system will be placed on a more satisfactory basis than it is at the present moment. In addition to Mr. Mackay's system there is also the Baltimore and Ohio Company, which is a very powerful railway system, and with which is connected a very important telegraph system, and no doubt, in any arrangement that is made with the land line companies, this line will have to be considered. What astonishes me is that this competition has gone on so long with such unsatisfactory results to the companies concerned. I therefore hope that before the next meeting I shall be able to put before you a statement with brighter prospects than I am prepared to submit on the present occasion, and I may also state that we shall endeavour to do this at as small a cost as possible. We are most anxious to protect our shareholders' interests, and return to the old 5 per cent. dividend ; but if for a short time I am compelled to ask you to accept a still further reduced dividend, I shall ask you to do so in the belief that it is done for the purpose of placing your property in a sounder and more productive position in the future. I now beg to move—"That the report of the Directors, dated the 10th July, 1885, together with the statement of accounts to the 30th June, 1885, annexed thereto, be and the same are hereby received and adopted, and that a final dividend be now declared of 3s. per share, free of income-tax, making, with the interim dividends already paid, a total dividend of 4 per cent. for the year ending 30th June, 1885." With regard to the dividend to-day, we are paying you at the rate of 3 per cent., making 4 for the year. It must be borne in mind that during the first six months we were working under the two shilling tariff, and during the rest of the period at one and eightpence tariff.

Mr. W. FORD seconded the motion.

Mr. GUESPON took exception to the fees paid to the Directors, and pointed out that the Articles of Association empowered them to have five Directors and not more than eight. He suggested that in future balance-sheets the cost of each security should be given.

Mr. GRIFFITH, referring to the unpleasant state of things now existing between the various submarine companies, and the disastrous consequences it had had on the returns of the Direct Company, said the question that they had to ask themselves was, Could the evil be remedied ? He was sorry to hear the Chairman state that there was a prospect of the dividend being reduced during the next six months. There was no doubt that while warfare continued between them both companies must suffer. If peace were restored, no doubt the other company would still gain something ; but so would the Direct Company. The public at present received a benefit from telegraphy for which they gave no adequate return. The public were the persons who received all the benefit ; therefore he thought they ought, without injury to the public at large, to consider whether some amicable arrangement could not be made by which the value of their property might be increased, and the prospect of good dividends brought within their view. He hoped before they met again that the able gentlemen who sat at the Board would be able to effect some advantageous arrangement. With regard to items of outlay, he found that during the last half-year they had spent a large sum in law expenses.

Mr. WM. FORD : It is quite an exceptional charge, and is not likely to appear again.

Mr. GRIFFITH said he found from the report of the Anglo-American Company just issued that the Directors of that Company intended to reduce their contribution to the reserve fund by £50,000. He wished to ask whether the Directors of the Direct United States ought not to take a leaf out of their book ? Of course, it would not be wise to diminish that fund if there was any prospect of their not being able to carry on the business in safety without increasing that fund.

Mr. JOHN NEWTON wished to give expression to the opinion that the Company would have no peace until it was prepared to fight the competing schemes. He thought if the shareholders were content to go for a few years without a dividend they would have very excellent dividends for ever afterwards. It was perfectly absurd for the existing companies with the vast experience they had had to talk about "squaring" or making arrangements with their rivals. He sympathised with what Mr. Guesdon said as to the fees of the Directors, and he would support that gentleman if he (the speaker) found that in the future the Directors were not prepared to take vigorous action and fight the competing undertakings. They could not make any arrangement that would be satisfactory until they had completely beaten their opponents.

The CHAIRMAN : I shall reply to Mr. Guesdon first. Mr. Guesdon taxed the Directors upon more grounds than one. I am very much astonished at the way in which he asks us the question whether we take any interest in the question of the reserve fund, and how we have invested it. I should think if there is one duty of Directors more important than another it is to see that the money that passes into their hands is faithfully and honourably invested. That we profess to do, and take the responsibility of it, and I may say that at the present time we stand in reference to our investments in the best possible position. We sold some securities to pay off the £100,000 debentures at a considerable profit, and those that we hold to-day are in excess of the price they cost us. Therefore you cannot blame the Directors for want of judgment or foresight. I do not claim any greater foresight than my neighbours, nor do I claim it for my Board, but this I will say, that there is no question more thoroughly sifted, and no subject as to which I invite every member of the Board to give an opinion, than that of our investments. I always ask my Board to co-operate and to give the best possible advice they can, which is given, and I take great care to see that it is properly carried out. Another question, and it is a very paltry one, to which he referred is the Directors' fees. If you want honourable and intelligent men to manage your business you must pay for them. There could be no better illustration of that fact than the history of this Company. This Company existed for four years without paying 1s. of dividend, besides being £100,000 in debt and very nearly falling into the hands of liquidators. The chairman of another company and I remonstrated, and endeavoured to bring about in a quiet manner, and without in any way disturbing the Board, a better state of things without effect. I then called together men in whom I had confidence, and we took your affairs entirely out of their hands. What has been the working of the Company since? The first six

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months after we took possession we paid five per cent. per annum, and we continued to pay that until the beginning of the year, and, as you know, we have placed £310,000 to the reserve fund, and we have paid off £100,000 debentures. Surely it requires some little intelligence to do that. I do not mean to say a word against your former Board as to their honour or position, but when we are brought into contrast, and especially remembering that they had £1,000 more than we have, all I do say is that when you get good men you must pay for them. But I am sure all reasonable men will agree that this is not the time, when we are trying as earnestly as we can do to maintain your dividends—which I hope we shall be able to do by-and-bye—to raise so paltry a question. I would say, in conclusion, in support of what Mr. Newton said, if you are going to fight be prepared to fight—though it does not follow that you will have to fight. If we cannot get a respectable dividend for you in one way we will in another. As to the remarks of Mr. Griffith, I can only say that I have put my views in writing that they may go forth to Messrs. Mackay and Bennett and all other interested parties; and if Mr. Griffith had listened attentively to my address he would have found that the whole of it dealt with the question of getting higher dividends and coming to a satisfactory arrangement. I am opposed to fighting if it can be avoided; but I am good for a fight where it becomes a necessity. I hope that common sense in this case will prevail, and that the American gentlemen will see, as we see, the necessity for an amicable understanding. They are not a public company, they are gentlemen using their own private property, and they have not gone into this business, and put a million and a half into it, without expecting some return. I am sure they want to get money out of it, and I believe they will be only too glad to come to us and make such propositions as will enable them to make that something out of it, and we shall also profit by the arrangement. As to Mr. Griffiths' question about the reserve fund, it depends entirely on the amount we receive. We have increased our reserve a little last year, and we have taken that from the floating balance; but we have been particularly anxious to help the shareholders in these trying times as much as possible, and we have given them something which would otherwise have been placed to the reserve fund. I hope the crisis is one which will soon terminate. He then put the resolution, and it was carried. Continuing, he said: The next resolution that I have to move is "That The Lord Hawke be and is hereby re-elected a Director of this Company."

Mr. WILLIAM FORD seconded the motion, and it was carried.

The CHAIRMAN next moved "That Admiral of the Fleet the Hon. Sir Henry Keppel, G.C.B., D.C.L, be and is hereby re-elected a Director of this Company."

Mr. UNDERDOWN seconded the motion, which was also agreed to.

Mr. WEAVER next proposed:—"That Mr. John George Griffiths and Mr. John Sawyer be and they are hereby re-elected auditors of this Company for the ensuing year, at a remuneration of £50 each."

Mr. NEWTON seconded the motion, and it was carried.

Mr. NEWTON then proposed a vote of thanks to the Chairman and Directors, remarking that he was sure they were all charged with a proper amount of fighting power.

Mr. GRIFFITH seconded the motion, observing that it was owing to the present Board that the Company had been able to achieve any success.

The vote having been cordially carried,

The CHAIRMAN said: I thank you on behalf of my colleagues and myself. I believe we have all the same object in view. Mr. Guesdon's suggestion of reducing the Directors' fees by a small sum I may say would be but an infinitesimal benefit to the shareholders; but if there were any necessity for it I am sure the Directors would bend to it as readily as any of the shareholders. As to our policy, it is a clearly defined policy. Our object is to get higher dividends, and to obtain them we shall endeavour to bring about a termination of the present competition in every possible way by peaceful means. If we cannot bring it about in that way, then I am, with Mr. Newton, a fighting man, and I hope we shall carry the day without much loss to the Company.

The proceedings then terminated.

The Globe Telegraph and Trust Company (Limited).

The twelfth ordinary general meeting of the shareholders of this Company was held on Tuesday last at the City Terminus Hotel, Cannon-street, under the presidency of Mr. John Pender, M.P.

The SECRETARY (Mr. William Payton) read the notice convening the meeting, and the minutes of the previous meeting, which were confirmed, and signed as correct.

The CHAIRMAN: Gentlemen, you have had the report in your hands for some days, and I presume that you will take it as read. Before moving the first resolution asking you to approve of these accounts I shall, as usual, make a few remarks on what has occurred during the last year. The principal point of interest to-day is that the dividend on our ordinary shares this year is less than the last one by ¼ per cent., or 6d. per share. The cause of this, gentlemen, is not very far to seek. It arises from the falling off in the amount that we have received from the Anglo-Telegraph Company. In the financial year, 1883, the Anglo and Direct Company paid us £46,356, in 1884 they paid us £44,795, and in 1885, the present year, they paid us £38,467, or £6,218 less than the year ended 1884, which is sufficient to account for the 6d. reduction of our present dividend on the ordinary shares. Now, gentlemen, you will no doubt ask me what are the prospects in regard to the Anglo-American, because in regard to the other companies—the Eastern and the Eastern Extension—there has been a steady increase of income from them, and I see no reason to doubt that that income will be permanent. Therefore, so far as the Globe is concerned those who are holders in the Anglo-American Company are materially benefited, and those who are holders in the Eastern Company have had no reason to regret investing in the Globe Company. It has given them additional security, and I may say at the same time that the Eastern and Eastern Extension Companies have materially assisted in maintaining the dividend. I may also add that the Brazilian Company has been a good source of income, and I see no reason to doubt that that income will be maintained. As to the Atlantic Companies we are really passing through a crisis. There are more cables in the Atlantic than the public requirements demand. Some of these cables have been laid, in my opinion, without regard to returns. It may be in the spirit of ardent enterprise, or it may have been from some personal consideration, but nevertheless the cables are there, and we have to contend with them. I cannot believe that those who have placed their money in the Atlantic are likely to allow it to remain there without some return, and it will become a question, no doubt, with those companies to consider what is the best course to pursue to bring about such a return as we believe they are fairly entitled to. I am speaking now as one of the largest shareholders in the Anglo-American Company, because the percentage that we hold in that company is something like one-third of the capital. Therefore, upon the success or non-success of that company, very much depends a good or indifferent dividend for the Globe. We are very safe so far as the other companies are concerned, and we shall endeavour to use what influence we possess to bring about between the Anglo-American, Direct, and the other Atlantic Companies such an arrangement as will secure a better dividend than we are receiving to-day. It is not for me to use threats of any kind, because that is not business, but we shall try to act in such a way, and I hope we shall be successful, as to secure the real object that we have in view. It may be that we shall have to pass through six, or it may even be twelve, anxious months, and I do not say that we may not have a still lower dividend. But the question must be settled in such a manner as to give a fair and reasonable dividend, and when we get into that state the Globe will be in a position to pay the dividend, though it has not been a large one, which we have paid during the last few years. I may mention that although we have received during the last few years only 3 per cent. from the Anglo-American Company, we have paid 6 per cent. upon our preference shares, and at the rate of 4½ per cent. upon our ordinary shares. Taking the two together, that gives an average of 5¼ per cent. The object of the Globe was greater security for the shareholders, but greater security never means a very large dividend. However, I may simply state that I believe the shareholders of the other submarine companies are watching very closely the different interests which they represent, and I think the day is not very far off when we shall be able at all events either to open up negotiations with these companies, with a view to a better adjustment of our relations, or to decide upon such a course of action as will make business unsatisfactory for those who have what we consider entered upon our ground without any sound reason. The new cables that they have put into the Atlantic have been put there without any chance that I can see of their leading to profit. They are not required, and consequently instead of contributing to develop the traffic, they have simply taken away a portion of that which existed. They have done worse than that—they have reduced the rates, and consequently have thrown into the sea £150,000 by those reduced rates, from which they have derived no benefit whatever. With these remarks, I beg to move "That the report and accounts of the Directors for the year ended 30th July, 1885, submitted to this meeting, be and the same are hereby received and adopted; and that a dividend be now declared of 3s. per share on the preference shares, making, with previous quarterly payments, 6 per cent. on the preference shares, and of 3s. per share on the ordinary shares, making, with the previous distributions, a total payment for the same period of 4½ per cent."

Sir DANIEL GOOCH, Bart., M.P., seconded the motion.

Mr. WEATHERLEY said he had gone carefully into the accounts which had been presented to them, and he could not but think, if the other shareholders had the time or inclination to go through them, they would be very much surprised if they compared the accounts of 1874 with those of 1885. He thought they ought not to be content with a 4½ per cent. dividend when they should have, according to what the prospectus held out, one of 8 per cent. They all knew that in dealing with the Board they were dealing with experts in telegraph matters—gentlemen who had had a great deal of experience, and, as their honourable Chairman had said, if they had experienced men to manage their affairs they must pay for their services. In 1874 there were ten directors on the Board, and their remuneration was £1,000, which he considered very fair pay, but nearly all of those gentlemen were directors of two, three, if not four of the other cable companies in which they held shares. Now they had six directors, and their remuneration was £1,500. The salaries in the company in 1874 were £787, and in 1885 they were £1,425. Similarly, he found that the other payments had proportionately increased. Having entered into the details of the expenditure to prove his case, and to show that the dividend had fallen 1 per cent., he proceeded to say that there were 7,000 odd shareholders in the company, many of whom were clergymen and widows, who looked for their quarterly dividends; and he said that it was upon the faith of the prospectus originally sent out, announcing that they were to have 8 per cent. on their deferred shares, that those people had put their money into the Company, but now they saw what they ought to have in dividends dwindling away by increased expenditure. He concluded by moving an amendment to the effect that the proposed dividend be declared, but that the accounts be not passed until they should be examined by a committee of investigation to be afterwards appointed.

Mr. JOHN NEWTON asked whether the Company paid income-tax?

The CHAIRMAN said, in reply to the last question, that they did not, and that they had taken counsel's opinion upon the subject, and their

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decision was that the income-tax should be deducted from the 6 per cent. preference shares, of which the ordinary shareholders got the benefit.

Mr. NEWTON contended that this was illegal, and that the money so deducted belonged to the Government.

Mr. PARNELL seconded Mr. Weatherley's amendment.

The CHAIRMAN: I am always pleased to hear criticism, more particularly when it is intelligent criticism, and bears practically upon the business of the Company. I must, in the first place, correct an error in Mr. Weatherley's statement. He spoke of a reduction of 1 per cent. in the dividend, and it is only ¼ per cent., which is a very material point.

Mr. WEATHERLEY: Pardon me, it was 5½ per cent. in 1874, and now it is 4¼ per cent.

The CHAIRMAN: You must never forget that we have now 7,500 shareholders to be dealt with, and that cannot be done at precisely the same expenditure as when you were dealing with 2,000. We have been constantly asked at these meetings to give as many details of the expenses as possible, and so we have tried to do. Again, we are not responsible for the new companies that have sprung up in the Atlantic. I think I can call gentlemen in this room to witness that we have in every possible way used our influence and power to prevent competition in the Atlantic. It is that competition alone that has reduced our dividend. I can truly compliment the Anglo-American shareholders who became shareholders in the Globe. Their dividend would have been 1 per cent. instead of what we are now paying. The Globe Company is not responsible for the management of other companies. We are shareholders in them, and why? The shareholders of those companies have exchanged their shares for Globe shares. They have not bought them with money; it has simply been an exchange, and that exchange necessitates a constant extension of our system. The salaries you say we have doubled. Well, admitting that we have, when we began with this Company we employed a smaller number of clerks, because we had a smaller amount of work to do. The salaries have been raised in the meantime, and we have had to increase the number of our office staff on account of the greater number of shareholders and the consequent increase of work. If Mr. Weatherley had been sitting by the elbow of our secretary when we were sending out our dividend warrants, and when everybody was in doubt as to what the income tax would be, he would have seen the number of calculations that had to be made, involving an amount of clerical labour that no one outside the office could form any idea of. As to rent and offices, I think no one would deny that ours is a very moderate rent for conducting a business with a capital of three millions. In respect to printing and stationery, I think the amount charged for them is small when you take into consideration the larger increase in the paper requirements of the Company. The item of postage stamps speaks for itself. As to the general office expenses, we might have given them, perhaps, more in detail. But I may here remark that the item of £249 includes a weekly audit by Messrs. Griffiths, Deloitte, Dever, and Co., which is a great protection to the shareholders. The legal expenses are £118. We pay our solicitor £100 a year. He attends every Board meeting. There are constantly questions cropping up in regard to what the other companies are doing, and we think it better to give this £100 a year than to give fees for each attendance according to the rate which solicitors charge. If we adopted the latter course we should pay in the long run a much larger sum than £100. In respect of the £18 in excess of that amount, it was spent, I may say, on counsel's opinion on this income tax question. [Mr. NEWTON: It was not worth the money.] I know there are men who would not differ very much from Mr. Newton on that point. But we took the opinion of the present Attorney-General and Mr. Rigby, and that opinion decided the matter in a way very much against some of our wishes, and we were bound to adopt that opinion or, as our solicitor tells us, make ourselves personally responsible. I may tell you that it is an adjustment—not a payment.

Mr. NEWTON: They why don't you pay that to the Government?

The CHAIRMAN: This question has been raised as if we were practising a fraud on the Government. Before we have our payments from these companies, the income tax is deducted and paid to the Government. It is perfectly straight, though there is a great deal of complication about it, but one thing is clear we don't rob the Government of 1s.

Mr. NEWTON: Certainly not, I do not say that you do.

The CHAIRMAN: On that point of legal fees I hope I have satisfied you. The whole of what Mr. Weatherley has complained arises from the question I have referred to, of the state of things in the Atlantic, for which we cannot be held to be responsible. Whatever influence we have will be exercised to bring about a better state of things, but anything like an inquiry into the expenses seems to me to be very unnecessary. Still, our solicitor tells me that the resolution moved by Mr. Weatherley and seconded by Mr. Parnell is in perfect order. As to the Directors' fees, I may mention that they were fixed by the shareholders in public meeting, and fixed at a time when they appreciated the value of the work of the Directors, and I have never heard until to-day any exception taken to them.

Mr. NEWTON said that it was thoroughly well known that no shareholder had fought so much against increasing the Directors' fees as he had, but he would rather that Mr. Weatherley withdrew his resolution, for he thought the Directors ought not to have any slight or censure passed upon them, for their services had been especially valuable to the shareholders.

The CHAIRMAN: I can only state this, that if there is anything meant to reflect in any degree upon the present body of Directors, they would not hold their position for one moment longer. I believe that we have served our shareholders well, and I think that the small interest which Mr. Weatherley holds in this Company would be very materially damaged if his resolution were carried to-day. This is a time when you require all the attention and energy of your Directors. You have honest men sitting on this side of the table. If you wish to have gentlemen who will always give way to your whims and ideas, your property will not be worth the paper on which it is written. The Company is in a thoroughly sound state. The companies we represent are thoroughly successful, and there is no immediate prospect of a very low dividend coming to us, and there is a very great prospect, if the property is properly handled, of our bringing about such a state of things in the Atlantic as will greatly benefit you. It is for you to support the gentlemen who have sat on this side of the table so long, and so honourably and faithfully looked after your interests. The course Mr. Weatherley is pursuing will have the effect of damaging your property.

A SHAREHOLDER: You invite us to criticise the accounts, and then when we proceed to move a resolution you say, "If you pass that you damage the property."

The CHAIRMAN: It is one thing to make a suggestion and quite another to pass a resolution such as this. One charge brought against your Board to-day is that of inviting proxies from the body of shareholders. We have not done anything of the kind. We have invited no proxies from the general body of shareholders. We have a very large interest on the part of those whom Mr. Weatherley so feelingly referred to, but I think their interests will be better secured in our hands than they would be if Mr. Weatherley's resolution were carried.

Mr. WEATHERLEY said that the Chairman, instead of giving him a satisfactory answer, had not satisfied him (the speaker) on any point. He maintained that the expenses were enormous, and that no satisfactory account had been given of the excessive increase under that head. The legal charges seemed to be exceptionally so, more especially in view of the fact that this was not a manufacturing concern where they were likely to have legal questions repeatedly cropping up. It was merely a trust where certain stocks and shares were held, for which, in due time, the money came in, and the dividends were sent out. Why on earth a solicitor was required at every Board meeting he did not know.

The CHAIRMAN: Mr. Weatherley has spoken of the enormous expenditure. Now, let that gentleman show me in any way where it is so extraordinary. He speaks of the solicitor's fees. I did not think that they were so very large; probably he knows more than I do about the subject. But we have considered in the interests of the Company that we should have our solicitor attending our meetings regularly, and that it is the cheapest way in the end. Will Mr. Weatherley point out where the expenses are enormous?

Mr. WEATHERLEY thought he had done so all the way through, and declined to go further into the matter. He was of opinion that now that the question of expenditure had been opened up, the shareholders ought not to dismiss it until they had some definite understanding that they would have a safeguard at least for the future outlay.

The CHAIRMAN: If this resolution is withdrawn I can state that we shall give every attention to satisfy Mr. Weatherley as to our accounts. If he, or any other gentleman, will call at the office between this time and the date of the next meeting, he shall get every possible information with respect to the accounts which it is in our power to give, and if he comes to the meeting and makes a practical suggestion we shall be glad to consider it.

Mr. NEWTON said that in deducting £35 income tax from the preference shareholders, the ordinary shareholders were charged something like £150 to £200. Therefore it was most unfortunate that they should have gone to the trouble of paying counsel £18 to enable them to deduct £35, at a cost of that amount.

The CHAIRMAN: The amount deducted is £2,886 11s. 5d., and that goes to the ordinary shareholders. He then read the original motion, and Mr. Weatherley's amendment.

Mr. BURT (the solicitor) suggested that the latter should be put as a substantive resolution after the report and accounts were adopted.

The CHAIRMAN objected, and said that such an investigation was calculated to cast a reflection on the Board.

Mr. BURT pointed out that the total expenses amounted to only 3l. per share.

A SHAREHOLDER thought that Mr. Weatherley should not press his amendment any further, after which there were cries of "Withdraw."

Mr. WEATHERLEY said that after such an expression of opinion he would withdraw his amendment, observing that he was content to call attention to the subject, and hoping that the next time they met the accounts would be prepared in a very different way, and that for the future, in the interest of the ordinary shareholders, every economy would be exercised.

The motion for the adoption of the report and accounts was then put, and carried unanimously.

Mr. SMITH wished to submit a resolution:—"That the Directors of this Company be instructed that no proxies of the Globe Telegraph and Trust Company should be given to the Directors of the Anglo-American Telegraph Company at a meeting of that company to be held at the Cannon-street Hotel on the 4th of August."

The CHAIRMAN: I am afraid you have come a little too late. Notice ought to have been given of this.

Mr. SMITH pointed out that the Chairman said they were not responsible for the loss of interest by the Anglo-American Company. He said that they were to a certain extent responsible, for if it had not been for their proxy at the last meeting, instead of £100,000 being added to the renewal fund, which he (the speaker) protested against, the Anglo-American Company this half year would have been able to pay a considerably larger amount than they did, and therefore the Globe Company would have been able to pay their proper and usual dividend. He was of opinion that they were responsible, especially when he saw three of the Directors of the Anglo-American on the Board of the Globe Company.

The CHAIRMAN: Your suggestion has come a little too late. I think I may state without any fear of breach of privilege that we, at a special meeting of the Globe Board, considered the question of giving proxies to

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the Anglo-American Company. We have always on previous occasions given proxies; but there was a strong feeling on the part of the Board that the time had come at the present crisis that there should be a little more given to the shareholders and a little less to the reserve. I do not think that we should depart from the principle, which all men who understand submarine cables hold, that the reserve fund should be looked after, and that it should always be maintained as far as the income of the Company will allow. But we decided at the meeting to address a letter to the Anglo Board, requesting them to seriously consider the question of paying some more dividend to the shareholders. That letter was addressed to the Chairman, and I believe it had considerable influence on the decision of the Board, and that you owe, to some extent, the dividend the Anglo-American Company are going to pay to the influence of the Globe Board.

Mr. JOHN BROWN seconded Mr. Smith's resolution because of the abominable use the Anglo-American had made of the proxies of the Globe Company.

The CHAIRMAN pointed out that this was irregular. They would accept it as their opinion, but not as a rule.

Mr. NEWTON thought Mr. Smith was scarcely entitled to ask them to stultify their position as Globe shareholders at a meeting of the Anglo Company. They must bear in mind that Sir Daniel Gooch held nearly £100,000 of stock in this Company, and how was this Board to exercise its vote to please both Mr. Smith and Sir Daniel Gooch if they happened to be at issue with the Anglo-American Company. They could not exactly restrict the Directors from voting in the Anglo-American Company, and seeing that they had so far got Mr. Smith's views to prevail on the Anglo-American Board this half year, he thought Mr. Smith was to be congratulated on the success he had obtained in getting them to carry out the policy he had so persistently and consistently advocated at the meetings of the Anglo-American Company.

The CHAIRMAN then proposed, and Sir SAMUEL GOOCH seconded, the re-election of the Marquis of Tweeddale to his seat at the Board, which was agreed to *nem. con.*

On the motion of the CHAIRMAN, seconded by Sir JAMES ANDERSON, Mr. Henry Gooch was also re-elected to his seat.

The auditors having been reappointed,

Mr. WEATHERLEY asked whether it was the intention of the Board to carry out the original intention of the Board with regard to their having an intelligence department. He felt strongly about it, and thought that the Anglo-American Company might have been supported better by this Company if the intelligence department had been established.

The CHAIRMAN: I am very glad to see that you take an interest in this matter, but I think you have a great deal to learn of the difficulties which the Directors have to contend with. When you make a little careful study of the various questions, and you will come to us, we will discuss them with you, and if there is any practical suggestion you can make to us we shall give you every possible encouragement.

On the motion of Mr. WEATHERLEY a vote of thanks to the Chairman brought the proceedings to a close.

The Cuba Submarine Telegraph Company.

The twenty-eighth ordinary general meeting of the shareholders of this Company was held on Wednesday, at the Company's offices, 61, Old Broad-street, Mr. Joaquin de Mancha (the Chairman) presiding.

The SECRETARY (Mr. James Scott) read the notice convening the meeting, and the report and accounts were taken as read.

The CHAIRMAN: Well, gentlemen, it is always pleasant for the Directors to meet their fellow-shareholders, and more particularly so when they have a very good account to render you, which they have to-day, and which I think the most fastidious cannot but consider as such. The accounts are so clear that it will require but a few words on my part just to go through a few of the items before I propose to you their reception and adoption. You will find that we are at peace with all our neighbours—even the Spanish Government, whom my friend Mr. Griffiths was rather doubtful about. They paid the money, which they acknowledged for a long time, but like many other impecunious people, although they acknowledged their debts, they do not always pay them. We have been more fortunate in this respect, and as you see, we received what we claimed for them, amounting to £1,137. With that and with the earnings of the half year we propose to recommend to you that a dividend be paid upon the ordinary shares of 10 per cent. The last time I had the pleasure of meeting you I almost predicted that this would be the case some day, but it has come upon us rather more quickly than I expected. But here it is, and I think the accounts are very favourable. The working shows an increase compared with the previous six months of last year. We have had about 2,000 more messages. Our income has not increased in that proportion, but still it is nearly £900 more than we had in June, 1884, and all the expenses are much about the same. There is a slight increase in the ordinary working expenses of about £160. We have been able not only to meet all our expenses, but to pay £2,000 towards the cable that we have purchased, and which we pay off gradually at the rate of £2,000 every six months. I think, taking everything into consideration, that we cannot but congratulate ourselves upon the prosperous state of our Company, which I hope will continue. Our cables are working fairly. They are, of course, getting a little antiquated, but still they are working as well as we could expect, and I hope they will continue to do so for some time to come. That, however, is one of those things which at any time we may have to face; we may be called upon to repair them more or less. This half year we have been particularly fortunate, we have had nothing to pay; whereas in the June of last year we had £2,000 to pay for the repairs that were then completed, and I therefore hope we shall not have any more great demands upon us. Of course there are sure to be some little amounts required to keep things in perfect order, and our manager in Cuba is so anxious and occupies his eyes so well with every minutiæ that I think we need not fear for any great outlay in that respect. With these few words, gentlemen, I beg to move "That the report and accounts now submitted be received and adopted."

Mr. ALEXANDER F. LOW seconded the resolution.

A PROPRIETOR asked whether the 1881 cable was to be paid for in ten amounts.

The CHAIRMAN, in reply, said the cable was to be paid for in twelve years. £17,500 had already been paid on account of it, and there was still £30,000 to pay.

Mr. THOMAS GREENWOOD remarked that the accounts were so clear that it was not necessary to enlarge upon them; and the shareholders were very much indebted to the Executive for the way in which they had conducted the business of the Company. Although the whole of the present prosperity could not be attributed to them, circumstances having favoured them, still it was quite possible for Directors, from want of judgment or otherwise, to spoil a good concern. That had not been so in this case. The property of the Company was improving much more rapidly than he had anticipated. It was possible if the traffic continued to increase, that they might be able to exceed the 10 per cent. dividend now earned. He hoped, however, the shareholders would be satisfied with the 10 per cent. until the reserve fund was largely increased to, say, 50 per cent. of the capital, or £110,000. They had still the heavy charges of the preference shares, and he thought the Board would be wise in endeavouring to merge in one the whole of the capital. It seemed to him unwise for small companies like theirs to have a divided interest. He did not propose to alter the status and privileges of the shares; but the preference shareholders might say, "We will take an ordinary share instead of a preference, though we will not do so unless we receive some compensation." In that event the Board might give them so much a share to make the conversion, out of their large reserves, which would be very suitable for such a purpose.

Mr. GRIFFITHS also thought it would be an advantage if any scheme could be devised for getting rid of the preferences. The preference holders had a prior security over all other claims on the income of the Company; and they could not get rid of them in a body without violation of the law. By some such scheme as the last speaker had mentioned, however, the Company might buy out the preference holders. He had attended all the late meetings of telegraph companies, and he could say that none of them had presented so satisfactory a report as the Cuba. All the other companies complained of the effects of the depression of trade, but he would like to know why this Company had not been affected by it? The Company had been prosperous for many years, and he believed it would go on and prosper.

The CHAIRMAN replied that the Company was not so much dependent upon the course of trade as were some of the others. There was a great deal of communication between Cuba and Spain. They did all they could to obtain business, but if bad times came upon them he hoped the shareholders would be as generous with them as they had been in times of prosperity. The Board would be ready to consider any well-devised scheme in respect to the preference shares.

The resolution was then put and carried unanimously.

The retiring director, Mr. Neil Bannatyne, was re-elected, as was the auditor, Mr. Greenwood.

Cordial votes of thanks were passed to the Chairman, Directors, Secretary and staff of the Company, and the meeting separated.

The Railway and Electric Appliances Company (Limited).

The second ordinary general meeting of the shareholders in this Company was held at the Cannon-street Hotel on Tuesday last, under the presidency of Colonel R. Raynsford Jackson.

The SECRETARY (Mr. William Shepherd) read the notice convening the meeting, and the report and accounts were taken as read.

The CHAIRMAN said: Gentlemen, I have sent you a circular which to a certain extent illustrates our present position, and you have all before you the report of the Directors. These two documents together place you in full possession of all the facts bearing upon the present position and interests of the Company. I shall therefore address you very briefly, and if I omit from my remarks any point in which you feel interested I shall be glad to answer afterwards any question you may choose to put to me. I think that the most important point for your consideration is that there is a great contrast between your position now and two years ago. Then you were entangled in a series of law suits which, in all probability, would have exhausted not only the capital then called up but all the uncalled capital. I do not know that I can give you a better idea of what those legal charges might have been than to state that there has already been expended in legal proceedings, which the Company has had to pay, £4,500. You may therefore imagine what would have been the result to the Company if the various actions had been pressed to their utmost extremity in the courts, and if the losing parties, as would undoubtedly have been the case, had appealed to the higher courts. I am happy to be able to inform you that we have succeeded by compromises which I consider advantageous to the Company—the circumstances connected with which you are already aware of—in getting rid of the risk of the frightful legal expenses to which I have just referred. And I may briefly point out to you what the effect of the compromises has been. In the first instance the capital of the Company was 91,732 shares upon which 12s. 6d. a share was paid, and 78,500 shares that we issued fully paid up, making the total capital of the Company £170,232. Under an arrangement with the litigants 41,131 of the 12s. 6d. shares were surren-

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dered, and under an arrangement sanctioned by you on the 13th of April, 1884, 50,350 fully paid-up shares were surrendered, making together 91,381 shares, leaving the capital of the Company, instead of £170,232, only £78,851. Upon the 50,701 ordinary shares remaining, £31,869 has been paid up, which with the 28,150 fully paid-up shares, leaves the capital of the Company entitled to a dividend at this time, if we could pay a dividend, at £60,019. Now, a most important compromise which has been made is this. You are aware that the fully paid-up shares held a preferential position, and suppose you had liquidated the Company when 78,500 of them existed, their preferential position of 7s. 6d. a share would have amounted to £29,437. The 50,350 shares that have been cancelled accounted for £18,881, and the preferential position occupied by the paid-up shareholders at present is only £10,566. Now, had the paid-up shareholders remained in their old position, and you had decided to liquidate the Company, the extra amount that you would have had to pay in, owing to the preferential position of those shareholders, would have been £18,881, or 7s. 5d. per share on all the ordinary shares of the Company. The difference is equivalent to all the uncalled capital of the Company, and it must be a great relief to you to feel that you have got rid of a grave and overwhelming incubus. You will be glad to hear that during the current half year the results at the Polmadie works have been very much more satisfactory than hitherto. There is a loss, but it is a very small one. The patents possessed by the Company have produced most satisfactory returns. Relatively large returns have been derived from the waggon-cover fastener, and there is still a prospect of our obtaining a considerable revenue from that small patent. The compensator, invented by Mr. Henry Williams, is likely to be of great importance to the Company hereafter. It has been tried by most of the principal railways. Several of them have given second, and one or two of them third orders for it, and Major Marindin, of the Board of Trade, has expressed his great approval of the invention, and has given Mr. Henry Williams permission to state that he does think well of it; so that I trust hereafter that we may get something towards providing a dividend for the Company out of the compensator. You are aware that trade has been for some time past in an extremely unsatisfactory and unprofitable condition, and companies like this, relying on the out turn of their works for a dividend, have necessarily been in a disadvantageous position. But we hope that the long continuance of bad trade will soon come to an end, and that there will be brighter prospects before us at no remote date. If that be so, I should hope, with the improvement in our ordinary trade, the success of our patents would help us towards putting the Company, with its reduced capital, into a more prosperous and satisfactory state. Looking to the report, there is just one feature in it to which I wish to ask your attention. It is that in the statement of the loss at Polmadie Works two of the items have been entered as affecting last year which have told against us, and yet had not resulted from the actual working of the establishment. The first is that £420 was paid to the old manager of the Company. His services were dispensed with. He was receiving an extremely high salary, and it was thought judicious on the part of the Directors to pay him up to the period of the termination of his engagement, and to dispense with his services, in order that new arrangements for placing the works on a better basis should be carried out forthwith, so that the losses of the year have been debited with £420 for which the Company have derived no direct advantage. There has been a reduction in the valuation of the stock of £700. That reduction ought properly to have fallen into the losses of the previous year. It should have been made at the beginning of that year. If it had been, the loss in the works last year would have been extremely small. You are aware that £2,000 is put down for Directors' remuneration. The Directors had no intention of receiving the full amount of remuneration put into the accounts which they are entitled to under the Articles of Association. But it turned out that, in order to get through with the important compromises to which I have referred, by which we got rid of 50,350 fully paid-up shares, it was necessary to come to an arrangement with the party who was blocking our action; and his arrangement was that certain expenses should be paid by the Directors, instead of being paid as authorised by the Company. The Directors have therefore paid £1,151, which the Company by your sanction would have paid, and which was a fair charge against the assets of the Company. That £1,151, therefore, must be regarded as a diminution of the loss put to profit and loss account. That is all the explanation which I have to give you on the report, and I trust that hereafter we shall be able to meet you in circumstances more favourable than those which are before us now. He concluded by formally moving the adoption of the report and accounts.

Sir George R. Prescott, Bart., seconded the resolution, which was carried unanimously without discussion.

On the motion of the Chairman, seconded by Mr. Alexander Smith, Lieut.-Colonel G. A. Elliot was re-elected to his seat at the Board. The auditor having been re-appointed,

The Chairman explained that Mr. Archibald Arrol had not offered himself for re election as a Director. Those who had co-operated with that gentleman had experienced the greatest satisfaction in all their relations with him, and regretted that he now ceased to be one of their number. Mr. Arrol, however, was resident in Glasgow, and it was difficult for him to attend regularly the meetings of the Board, and he felt it was his duty to retire.

A vote of thanks to the Chairman, proposed by Mr. Herbige and seconded by Mr. Arrol, was cordially carried, the latter gentleman expressing his regret that his sense of duty compelled him to sever his connection with the directorate, and an earnest hope for the future success of the Company.

The Chairman briefly acknowledged the vote, and the proceedings terminated.

Submarine Telegraph Company.

Report of the Directors to be submitted at the meeting of the proprietors of the Submarine Telegraph Company, to be held at the offices of the Company, 2, Throgmorton-avenue, London-wall, E.C., on Tuesday, 4th August, 1885, at one o'clock p.m.

The accounts for the six months ending 30th June, 1885, show the gross receipts to have amounted to £66,795. 16s. 11½d., and a net result which enables the Directors to add £8,334. 6s. 5d. to the reserve fund, and to recommend a dividend at the rate of 15 per cent. per annum, leaving a balance of £889. 4s. 2d. to be carried to the next account. The receipts for the six months exceed those for the corresponding months of the year 1884 by £4,038. 5s. 0½d. This increase arises principally from the general traffic, although there has also been an increase in the receipts from the special traffic transmitted by the Indo-European Company over the wire in the Norderney cable, which they lease from the Post Office. The average length of the messages, however, in the six months has been shorter, being 11·72 words against 12·04 words in 1884. On the other hand, the number of messages transmitted has been 85,011 more than in 1884. Besides the increase in the receipts, there has been a decrease of £1,229. 5s. 1½d. in the total expenses. The cost of repairs to cables has been £1,858. 8s. 4d. less than in 1884, but the other items of expenditure show together an increase of £629. 3s. 2½d., which sum includes £139. 9s. 10d., a part of the extraordinary expenses referred to in the last report as having been incurred in overhauling and repairing the steamer in the half year ending December, 1884. The decreased cost of repairs to cables is due chiefly to the two Government cables to Holland having been, the one completely, the other partially, renewed by the Post Office, and, consequently, being better able to bear the strain of fishing gear and anchors coming in contact with them. In 1884 these cables were interrupted for 252 days, and in 1885 one of them was not interrupted at all, while the other was interrupted only for a period of 81 days, in the course of which a new length of about 32 miles was inserted in it. The Company's cables in the Channel have also been remarkably free from interruptions, and at the present time all the cables worked by the Company are in good working order. The term of the agreement under which the Indo-European Company worked a wire in the Government cable to Norderney expired on the 24th December, 1884, and fresh arrangements have been made with that Company for continuing the working of the Norderney wire, and also for a wire in the cable of the German Union Telegraph Company, under which the Company will receive a small increase of income.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. July 29.		Business Done Week Ending July 29. Highest.	Lowest.
Anglo-American	28½,	29½	29½	28¾
Do. Preferred	49,	50	49½	47¾
Do. Deferred	7,	8	8	—
Brazilian Submarine	11,	11½	11 3-16	10 15-16
Cuba	12½,	12¾	12¾	—
Do. Preference	18,	19	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	12,	12½	—	—
Direct United States Cable	8½,	9½	8¾	8¾
Eastern Telegraph	11⅜,	11⅝	11⅝	11⅝ x.d.
Do. 6 per Cent. Preference	13½,	13¾	13 9-16	13½ x.d.
Do. 5 per Cent. Debentures, 1899	107,	110	—	—
Eastern Extension	12⅜,	12⅝	12 13-16	12 11-16x.d
German Union	9½,	9¾	9¾	—
Globe Telegraph and Trust	6⅝,	7⅛	7⅛	7
Do. Preference	12⅜,	13⅛	13 1-16	12⅝
Great Northern	13⅞,	14½	14½	14⅛
Indo-European	30½,	31½	31	—
Reuter's	7½,	8	—	—
Submarine	185,	195	192	—
West India and Panama	⅞,	1	⅞	—
Do. 1st Preference	8,	8½	8 5-16	—
Western Brazilian	6½,	6¾	6¼	6 1-16
Western Union 7 per Cent. 1st Mortgage	120,	124	—	—
Do. 6 per Cent. Sterling Bonds	103,	105	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅛,	¼	—	—
Oriental	⅛,	¼	—	—
United Telephone	11½,	11¾	11 7-16	11½

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	—	—
Do. (fully paid)	3½,	3¾	3⅞	3⅞
Hammond Light (£3 15s. paid)	⅛,	¼	—	—
Swan	⅛,	¼	—	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	86½,	87½	87	— x.d.
India Rubber, Gutta Percha, and Telegraph Works	24,	25	24¾	24½

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THE INTERNATIONAL INVENTIONS EXHIBITION.

Dynamo-Electric Machinery.

BY W. M. MORDEY.

The Thomson-Houston Dynamo.—In considering a dynamo machine it is convenient, in the first place, to classify it, to define its type, and then to proceed to examine its details in order to find in what particulars it is an improvement on its predecessors. In most cases this task is a very simple one. A glance at almost any dynamo is usually sufficient to enable its class to be determined. Just as nearly all the early generators were of the Pixii-Saxton class, so now the great majority of successful continuous current machines are of the types with which the names of Pacinotti and Gramme, or of Siemens and Alteneck are connected. But in the very interesting machine now under our notice this usually easy task of general classification is found to present the first of a series of difficulties. In fact, it may be said that in every part of this dynamo, in its mechanical construction as well as in its electrical action, we have something unusual. Peculiarity has marked it for her own. The general form of armature, the construction of the armature core, the winding, the commutator, the general magnetic system, the collection of the current, and the method of regulation—all these matters present points of interest which well deserve study.

The feeling produced by a study of this machine is one of surprise that it should work well. There are so many things about it that are not in accordance with accepted ideas of what is best in dynamo construction, that the writer believes that a consideration of its details and action, in the absence of a knowledge that it worked satisfactorily, would be sufficient to cause most electrical engineers unhesitatingly to come to the conclusion that it would not answer, especially as a high tension dynamo.

The Thomson-Houston armature belongs to the drum, or Siemens-Alteneck type, but is distinguished from its prototype by having the form of a hollow sphere instead of a cylinder —the difference is not one of principle. This spherical form is almost peculiar to this dynamo, the only other instance known to the writer of the employment of a spherical armature being the electromotor of Bürgin, shown at the Paris Electrical Exhibition of 1881. But the Bürgin motor armature resembled the Thomson-Houston armature in no other point than in its external spherical form; its internal construction, as well as its mode of action, being quite distinct from the latter. The iron core of the Thomson-Houston armature, as will be seen from the description given in last week's article, is a hollow shell constructed of cast-iron plates and bridge-pieces or ribs, overwound with iron wire. It would be interesting to know why the inventors left so large a space vacant in the interior of the core. We know that Edison employed a hollow drum in his dynamo—for the Edison armature, as made with the large core of wood, is magnetically hollow—and that other makers, Heinrichs and Gülcher for instance, have made armatures with large inoperative spaces in them; but in no other case is the writer aware of the existence of a dynamo having so large a magnetic vacancy as the machine under consideration. An examination of the distribution of the iron of the core shows that the main portion of the lines of force within the armature probably pass by the iron wire. The cast-iron portions of the core consist of two concave plates, as shown in Fig. 3 in the last Supplement, and of a number of cross ribs. We say that the iron wire plays the most important part in magnetically connecting one pole of the field-magnet with the other, because it will be evident that the ribs, being placed at right angles to the lines of force, can assist but slightly in this action, their position inside the shell formed by the iron wire also to some extent relieving them of any great share in an action which would necessarily render them liable to inconvenient heating by eddy currents. The end plates are further from the pole pieces than the iron wire is, and on this account must be to some extent withdrawn from an action which in their case also would be deleterious.

The field-magnet system need not be explained. It will be understood from the description already given. In the field-magnet of the Thomson-Houston dynamo every consideration which would weigh with English electricians seems to have been set at defiance. The magnets are mainly of cast iron, and, like the armatures, are mere shells. Although the poles present a large surface to the armature a reference to a sectional view shows that the directly magnetised cylinder is continued into a polar prolongation through an acute angle, the whole being of cast-iron, and that a considerable portion of the centre of the pole-piece is cut away altogether for purposes of ventilation. Again, the yoke joining the ends of the hollow cylindrical cores is necessarily very long and thin, and passes dangerously near to the poles, so that a "leakage" or "short-circuiting" of lines of force would appear to be unavoidable. On the other hand, the field has some distinct advantages. The yoke, as well as the cores, is magnetised directly by the solenoid, thus, to some extent, compensating for its extreme length. The armature is well enclosed by the pole pieces, and presents a large surface to them; and, in addition, the armature core itself is brought within the direct magnetising influence of the solenoids. The machine would no doubt give a considerable E.M.F., even if it had no iron in the field-magnets. Then, again, the magnetic system is self-enclosed. The yoke bars, although they may afford facilities for magnetic short-circuiting, act as guards to the armature, and prevent the straying of lines of force outside of the machine. It is probable that watches are not seriously affected by these dynamos.

But probably the feature of this machine which strikes those accustomed to the more conventional forms as being more than anything else likely to give trouble is the small number of coils on the armature and of plates in the commutator. Professors Thomson and Houston have, however, not been daunted by any difficulties which might result from short-circuiting or open-circuiting coils of large inductive capacity. They have not only met and overcome these difficulties, they have gone further, and for regulating purposes have introduced momentary short-circuiting of the whole armature, with the necessary accompaniment of violent pulsating changes of current through the whole circuit.

The current is "redressed" by means of a 3-part commutator. The ordinary 2-part Pixii commutator, which has been so largely used in the Wilde and other early forms of generators, has the disadvantage that it yields a discontinuous current whether in the external circuit of a generator or in the internal circuit of a motor, as it either breaks the circuit or short-circuits twice in each revolution. By combining several of these commutators in one, Brush succeeded in maintaining continuity, and Thomson and Houston accomplish the same object by their arrangement of the three coils with the three commutator plates; although in some phases of the commutation this advantage of continuity is abandoned. With this arrangement, as with all true commutators, the diameter of collection is at right angles with the diameter of commutation. In fact, there is not strictly a "diameter" of collection at all. In the Pacinotti-Gramme collector the diameters of commutation and of collection coincide, and there the brushes are placed, being connected with the active coils only through the junctions of the idle coils; but with true commutators the brushes are connected with the ends of the working coils during the whole time that these are active. In this commutator only three plates are used, the coils being connected at one extremity, thus dispensing with three commutator plates which would otherwise be required. The effect of this, and the point in which it differs from other commutators of the same class, is that when a coil is thrown out of connection its circuit is opened at one end only instead of at both ends, as is usual. It is interesting to note that in the earlier Brush dynamos, many of which are still working, a rather similar arrangement obtained, the "idle" coils being put out of connection with the brush at one end only, the other end remaining in contact with another brush.

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The series of arrangements of the three coils under normal circumstances need not detain us. Each coil is twice out of circuit in each revolution, during which the other two coils are in series with each other. Twice in each revolution two of the coils are parallel, and the third coil is in series with them.

One point is, perhaps, worth alluding to in connection with the parallel working of two coils. As they are, in this case, separated by 120° it will be evident that they are not traversing regions of the field of equal intensity, and on that account their E.M.F.'s are not equal, and the output is something less than that which would be produced by the sum of the E.M.F. of the highest of the parallel coils and the E.M.F of the series coil.

In connection with this question of the construction of commutators it is noteworthy that the two dynamos which have been most successful, and have been most extensively applied as high tension generators, possess certain distinctive qualities in common. The armatures are wound with a small number of large coils, part of which are cut entirely out of the circuit, while some are in series with others, which latter are connected parallel. The effect of this is that with a given winding a greater difference of potential is obtained at the terminals for the same E.M.F. in the armature than would be possible were the Pacinotti-Gramme collector used, which, as it places the two sides of the ring parallel, reduces the E.M.F. available to one-half of the total. Comparing this with the Thomson-Houston armature we see that even when one-third of the wire is removed from the circuit, the remaining two-thirds are in series. Similarly, the Brush armature, with its eight coils, two of which are always out of circuit, may be looked upon as having six working coils, and may be compared with a Gramme 8-coil armature with brushes, each always touching two segments; four of the six coils are always in series. A Gramme collector, of course, could only place three of them in series.

It will be evident that for the purpose of obtaining the greatest difference of potential with any given winding these commutators with the series connections are more suitable than the ordinary continuous connections used with collectors.

The brushes of the Thomson-Houston dynamo are four in number, but as the two brushes on each side of the commutator are directly connected, each pair may for all practical purposes be regarded as forming one wide or thick brush. This arrangement was used in the Siemens dynamos some years ago, and is now employed in the Hochhausen machines, in each case with the apparent object of diminishing the armature resistance by removing coils from the circuit when they were passing through the portions of the field where the direction of the E.M.F. changes. This plan has been abandoned in the case of the Siemens dynamos, and, the writer believes, also in some of the recent Hochhausen machines, probably because the "neutral" region was found to be very small, and that, although the coils so treated had not sufficient E.M.F. to be of much use as a source of current to the line, they generated wasteful and injurious currents when short-circuited through the brushes. A short-circuiting device similar in principle and effect was also used for a considerable time in the Weston dynamos, and may even now be seen in one of these dynamos, of an old design, working in the electric lighting shed—viz., the placing of the plates obliquely on the commutator, thus causing the ordinary single brushes to bear on and connect a greater number of plates than they would if the plates were straight and parallel with the axis.

The application of the wide or double brushes in the Thomson-Houston dynamo differs in some essential points from the foregoing instances, in which the connections of the armature coils were on the continuous or Pacinotti system. As the commutator plates are arranged around the commutator one after the other, each subtending an angle of nearly 120°, and not side by side, brushes enclosing a considerable angle are required in order that the two commutator plates connected respectively with the ends of the adjacent coils may be brought into contact with one brush when they are required to be placed in parallel connection. The same, or a very similar object, is accomplished in the Brush commutator—with which this invites comparison, there being more than a distant resemblance between them—by using a single brush, and arranging the commutator plates side by side through the proper angular distance. A plan very similar to that used in the Brush dynamo appears to have been used in this machine during the earlier stages of its growth, but given up in the recent forms, no doubt in order to meet the requirements of the very striking regulation system.

It may be useful, before considering the peculiar Thomson-Houston regulating system, to glance briefly at some general conditions of the question of regulation, and to ascertain in what directions inventors have mainly worked in their efforts to control the output of the dynamo to meet the requirements of the circuit. Alike in the constant current system of working, which is by far the most practical one for arc lighting, and in the constant E.M.F. system, which, in one form or another, best lends itself to incandescent lighting, a most important point is the automatic regulation of the dynamo to meet the requirements of the circuit. Of these two systems the difficulties of the former almost entirely present themselves at the generator, where they may be met and overcome. The external circuit requires only a constant current. The latter system, on the other hand, presents difficulties not only at the generator, but also in the external circuit, where a constant potential difference is called for at perhaps many points—a constancy which is not perfectly attainable.

The problem of the regulation of dynamos, either automatically or by hand, to give constant current or E.M.F., has been in almost every case approached in one of two ways, other than effecting this by the method of winding or "compounding." Either the strength of the field has been varied, or the brushes have been moved on the commutator till the required result has been obtained.

Maxim, and more recently Hochhausen and others, have employed devices whereby the object was attained by means of rather complicated electrically-controlled mechanism, which moved the brushes to suit the requirements of the varying circuit, or to compensate for irregularities of speed. The collectors in these cases were of the Pacinotti type. There are several objections to such methods. The field expenditure is as great for a small output as for a large one; the loss from eddy currents is greatest when the least amount of work is being done; and the collection of the current, especially in constant current systems, is attended with difficulties arising from the necessity for placing the brushes in position more or less remote from the neutral line in the case of collectors, or the maximum line in the case of commutators.

The other and more usual method of effecting regulation is by varying the strength of the field, making it sufficient to generate the required constant current or maintain the required constant potential difference at the dynamo terminals or elsewhere, and no more. In series dynamos this is best accomplished by employing a variable shunt placed across the terminals of the field-magnet coils; in shunt dynamos by the interposition of resistance capable of variation. In both of these cases the resistance should be capable of perfectly gradual variations, such as may be obtained by the compression of carbon, or by the use of a liquid resistance with movable electrodes. It should not be variable by a step-by-step arrangement, as this produces a jerky and irregular effect in the circuit.

This principle of field regulation was at one time sought to be carried into effect—in the first instance, we think, being proposed by Brush in connection with series dynamos—by dividing the field winding into several parts, one or more of which could be removed from the circuit as required, thus varying the excitation of the magnets. Unless the divisions are very numerous—even if there were no other drawback—this method would not give good results.

There is another plan, one which has found several advocates, amongst them Edison. According to this it has been proposed to vary the field, not by alteration of the magnetising current, but by having a non-magnetic gap in some part of the magnet, usually the yoke, which gap could be filled to the required extent by a movable iron plug playing the part of a variable "magnetic resistance;" or by placing a "keeper" on the poles which acted as a magnetic shunt on the armature, in the manner familiar to us in the magneto-electric shocking or

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"medical" coils, to vary the useful power of the field magnets. A combination of the two methods of brush-movement and shunt-current-alteration was proposed by Edison, viz., to use an additional brush, to which one end of the field shunt was connected, the other end of the shunt being joined in the usual way to one of the ordinary brushes or terminals. This additional brush was to be moved on the commutator, between the two main brushes, to the position which was necessary to obtain the proper current for the shunt. As any difference of potential, up to that maintained between the main brushes, could in this way be obtained for the field circuit, the shunt current could be varied without the use of additional resistance coils, or the employment of divided field windings. Perhaps the difficulties connected with the construction of incombustible and infusible brushes prevented the extensive application of this very ingenious idea.

The Thomson-Houston regulating system is a most novel and interesting one. The problem of obtaining constant current has certainly been attacked in a very novel manner, the method employed being made to yield results of a character far above what might have been expected. It is not necessary to enter into any examination of the ingenious apparatus by which these results are obtained; it has already been described. Suffice it to say that the apparatus appears to be very sensitive, and to respond promptly to all calls made upon it. By watching the action of the regulating devices it can be seen that they are in a state of constant movement, correcting slight changes in the current caused by variations of speed or resistance. The method is based on the first one mentioned above, viz., the movement of the brushes, but the brushes are moved in a peculiar manner. Bearing in mind what may be called the normal position of the brushes it will be seen that they correspond with the line of maximum effect, one coil being cut out of circuit when it is in a position incapable of adding greatly to the E.M.F. of the other two coils, which are in series with each other, and being brought into circuit again only when its E.M.F. is of value in the reversed direction. When the external resistance is reduced each double brush is made to enclose an increased amount of the commutator, the forward brush of each pair being brought forward, thus lengthening the time during which the coil about to traverse or traversing the "neutral" portion of the field is kept in circuit; the back or rear brush at the same time being made to retreat, thus, at an earlier stage, enabling it to place the coil which is emerging from the neutral region in parallel with one of the active coils. The movement backwards of the rear brush is only one-third as much as the forward movement of the leading brush.

Thus commutation is delayed, the "idle" coil, instead of being removed from the circuit, being kept parallel with another coil when it is producing no E.M.F., or is producing one in a contrary direction. And the reintroduction into the circuit of this "idle" coil is made to occur before it has got over its idleness, and when it is only capable of short-circuiting a coil which is trying to be useful.

And not only is this done, but the brushes are still further widened until the forward brush of one pair is actually made to touch the segment on which the rear brush of the opposite pair still rests, thus short-circuiting the whole armature through that segment. This is done six times in each revolution. The effect of it can only be to successively withdraw the current from the fields and external circuit, as each segment in turn is made to connect the brushes. The boldness of this method is very striking. The effect on the economy of the generator and on the steadiness of the current must be serious. The writer imagined that the movements of the brushes did not actually effect short-circuiting, except when the external resistance was very small —that it was only rendered necessary by extreme requirements of regulation—but he is assured by Mr. Cudder, the courteous American engineer in charge of the installation, that this is not the case, and that short-circuiting commences at a comparatively early stage, when only a small reduction has been made in the resistance of the circuit, and therefore when a high E.M.F. is being produced. That it should be possible to reduce the E.M.F. of a high-tension generator by means of what is really a rapid short-circuiting make-and-break across the armature is certainly what few electricians would have believed.

Another feature of the Thomson-Houston dynamo, and a very ingenious one, is the air blast used in connection with the commutator and brushes, by which the formation of dangerous arcs at the brushes is prevented. The jet of air is directed against the commutator immediately facing the leading brush of each pair, and as there is a clear air passage between the segments of the commutator, the formation or the continuance, of arcs across this space is prevented. This air blast must act in another useful way also. It is no doubt well known that sparks occur at a heated brush much more readily than at a cool one. The reason for this is that combustion, melting, or volatilisation of particles of the metal, by the slight arcs at the contact points, takes place with the greatest facility when the brushes are hot. The air blast will do much to keep the brushes cool, and in this way to prevent destructive wear. It is only in connection with the leading brushes that the air blast is used, because it is at these points only that any rupture of the circuit takes place. At the rear brushes, the coil which has passed through its "idle" phase is placed in parallel with one of the active coils—an operation not accompanied by any spark beyond that due to the passage of current through a rubbing contact. It will be gathered from what has been already said that one effect of placing the "idle" coil too soon, or keeping it too late, in parallel with its active neighbour is a considerable back-flow of current through it. A confirmation of this is found at the brushes, Mr. Cudder informing the writer that when sparking takes place at the rear brush it is always of a more destructive character than at the leading brushes, a result doubtless to be traced to the passage of large back currents.

The air blast is a most important and admirable feature in this machine, the very breath of its nostrils, and it is no doubt mainly by its assistance that the inventors have been able so succesfully to overcome the apparently insuperable difficulties of dealing with the large and violent changes at the commutator.

W. H. Allen and Co., Lambeth, exhibit two Kapp dynamos, one for arc and the other for incandescent lamps. The latter is coupled direct to a high speed twin engine of the Allen type. The two cranks are placed at opposite angles in order to obtain a perfect balance of the working parts. With most makers of direct driven dynamos the tendency has been to accommodate the prime mover to the dynamo by designing special engines which might run at 1,000 revolutions a minute, or even faster, if possible. Now it cannot be said that these so-called rotary engines are as yet perfect, and free from the two objections of using too much steam and of breaking down occasionally. Messrs. Allen have wisely, therefore, determined not to spoil a good engine by trying to make it run fast enough for the usual commercial dynamo, but to build a dynamo of their own which shall run slow enough for driving direct by a substantial and economical engine. We illustrate the plant as exhibited in the electric light shed at the Inventions Exhibition in the annexed perspective view. Engine and dynamos are placed upon the same cast-iron bed, and the engine shaft is coupled direct to the dynamo-spindle. At a speed of 340 revolutions a minute the external electromotive force is 110 volts, and the current 150 amperes. The machine is self-regulating, but slightly overcompounded, so as to maintain, when governed by a centrifugal governor of the Pickering type, a constant electromotive force at the end of its main circuit.

As will be seen from our illustration, and from the annexed diagram (Fig. 2), the field magnets are semicircular, by which arrangement a maximum length of surface for the application of the exciting coils is obtained with a maximum length of, and therefore a minimum resistance in, the magnetic circuit. The core of the magnet is 3½in. by 20in., or 70 square inches in cross section, and the exciting coils are wound on cast-iron formers, which can be slided over the magnets very much in the same way as a scabbard over a sword. The shunt coils are wound with ·083 wire, and the main coils with ·160

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wire, six of these being coupled parallel. The resistance of the shunt is 22 ohms, that of the main ·023 ohms, and the total exciting power on one half of the machine is 12,000 ampere turns. The construction of the armature will be seen by our Figs. 3, 4, and 5; it is of the Gramme type, but of exceptionally large diameter and very heavy, so that at the low speed of 340 revolutions the required E.M.F. of 110 volts shall be obtained. The armature is 16in. in diameter and 24in. long. The core consists of soft charcoal iron wire wound upon a supporting cylinder of gun metal, which in its turn is keyed to the spindle by two sets of arms as shown in Figs. 2 and 3. The surface of the supporting cylinder is perforated, and presents, when opened out into a plan (Fig. 5), the appearance of a grid with alternating bars. The object of this arrangement is partly to lighten the cylinder and partly to admit air to the interior of the core. The cylinder is stiffened by having four flanges, F, cast on, which in contour

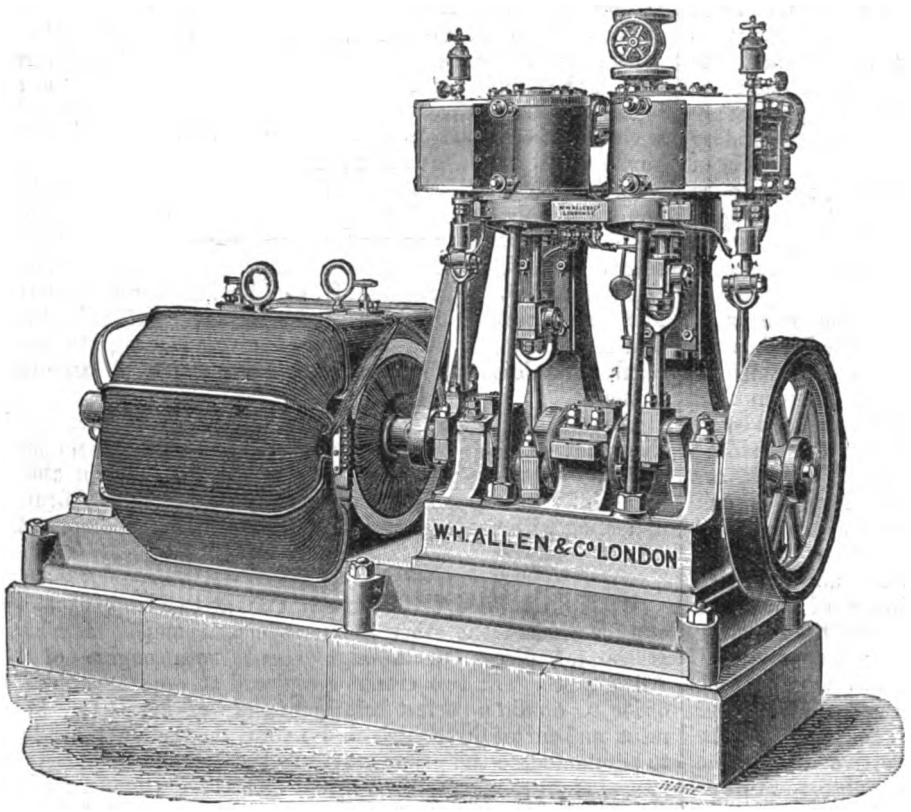

FIG. 1.

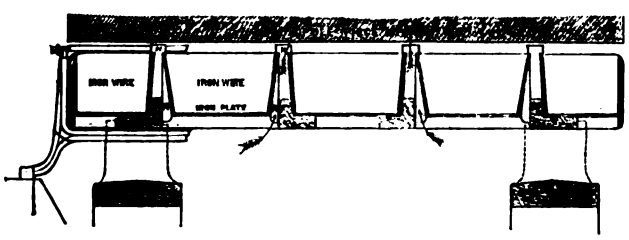

FIG. 4.—Longitudinal Section through Armature.

are not circular, but provided with radial extensions or driving horns, H, for the purpose of transmitting the driving power in a positive manner to the copper conductor, which does the work. With so strong a field as that employed in the Kapp dynamo it is absolutely necessary to make some provision by which the wire shall be prevented from slipping on the surface of the core. In many machines the friction produced by the external binding is alone relied on for carrying the coils through the field, but experience has shown this to be insufficient. Even if the wires are not bodily torn off the armature by the magnetic resistance of the fields, they shift and work on the surface of the core, and it is only a question of time when the insulation will be destroyed and the machine break down. The driving horns are provided with narrow ribs, R, which keep the core a slight distance off the horns, and air is thus allowed to enter between them and escape between the outer coils of the armature winding, which does not completely cover the surface. The driving horns are tipped with fibre ferrules, and distance pieces of the same material are inserted between the wires at stated intervals, so as to subdivide them and hold them firmly in place. Before commencing to coil the iron wire on to the supporting cylinder, a thin band of iron is lapped round it so as to cover the openings in the grating, and thin iron washers (in halves) are placed against the flanges, and are held in place by the driving horns. These washers are insulated with asbestos paper to prevent direct continuity of the metal throughout the length of the armature. The armature is wound with 200 turns of ·165 square conductor; resistance from brush to brush, ·07 ohms; total weight of copper on armature, 90lb. The weight of copper on field magnets is 410lb.; therefore, total weight of copper on the machine 500lb. The weight of engine and dynamo com-

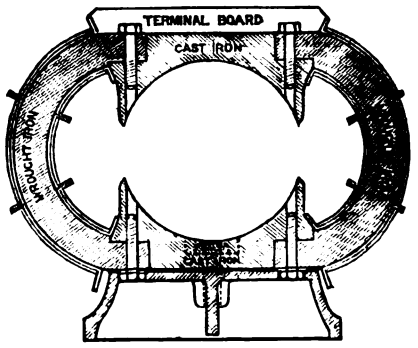

FIG. 2—Transverse Section through Field Magnets.

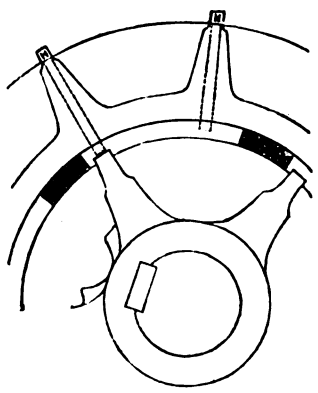

FIG. 3.—Transverse Section through Armature.

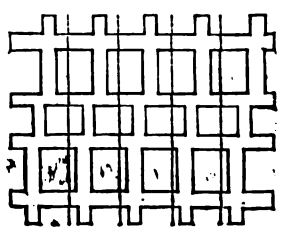

FIG. 5.—Supporting Cylinder, cut parallel to Spindle and opened out. Arms on dotted lines.

bined is nearly three tons. The current through shunt is five amperes, which gives a density of 925 amperes per square inch. The usual working current through the armature is 155 amperes, being at the rate of 2,840 amperes per square inch.

The arc light dynamo exhibited by Messrs. Allen and Co. has an armature similar to that just described, but is much smaller. The armature is 8½in. diameter by 11½in. long, and is wound with thirty-six coils, each coil consisting of sixteen turns ·057 wire. The field magnets are placed vertically, and are straight slabs of iron 2in. by 8in. in cross section. The machine is driven by belt, and at a speed of 1,150 revolutions gives a current of 15 amperes and an E.M.F. at terminals of 300 volts, feeding six Slatter arc lamps. The total length of conductor wound on the armature is 415 yards, which corresponds to about 1·4 yards per volt in the external circuit.

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NOTES.

NEW TELEGRAPH LINE.—A new telegraph line has been established between Wolfeborough and Alton Bay, *vid* Dover, N.H.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 31st July were £2,652.

THE TELEPHONE IN BELGIUM.—On the 3rd inst. telephonic service was opened between Ostend and the exchanges at Brussels and Mons.

THE TELEGRAPH TO MERV.—Intelligence from Merv reports that the Russian authorities intend continuing the telegraph line from Merv to Bokhara.

STRUCK BY LIGHTNING.—During a violent thunderstorm at Northampton on Wednesday a young man named Soden, assistant to Mr. Cockerell, fruiterer, was struck by lightning, his sight being injured.

THE ELECTRIC LIGHT IN NEW YORK CITY.—The quarterly report of the Commissioner of Public Works shows that at the close of the quarter ended 30th June 703 arc lamps were in use in the city.

THE COLONIES AND THE TELEGRAPH TREATY.—According to the *Norddeutsche*, the Australian Colonies of New South Wales and Tasmania have announced their entrance into the International Telegraph Treaty.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 31st July are £2,560, as compared with £2,791 in the corresponding period of 1884.

ELECTRIC LIGHT FOR STEAMSHIPS.—The new Chinese war ships are provided with excellent arc lamps. The "Chin-Yuen" and the "Ting-Yuen" have search lights of 40,000 carcels. The third, the "Tae-Yeen," has only electric side-lights.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending the 31st ult. were £2,124, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

A CURIOUS ACCIDENT.—The cover of a manhole on the underground electric wire conduit in Beekman-street, in New York City, became charged with electricity one day last week, and gave severe shocks to several horses. One animal was thrown down.

CITY AND GUILDS EXAMINATION.—We understand that Mr. James Crombie, Eastern Telegraph Company, Glasgow, has taken second class honours in "Telegraphy," under Principal Jamieson, at the College of Science and Arts, Glasgow, during the past session.

TIME INDICATING BY TELEPHONE.—One of the most useful adjuncts to the telephonic service in America is an arrangement whereby any subscriber is enabled to ascertain the exact time at any minute of the day by simply placing his telephone receiver to his ear.

NEW FRENCH CABLES.—The projected establishment of telegraphic cable communication between the French colonies of Rio Nunez, Grand Bassam, Porto Novo and the Gabon, was adopted by the *Sénat* at the sitting of the 31st ult. The West African Telegraph Company have the concessions.

THE TELEPHONE IN FRANCE.—By decree of the President of the Republic, subscribers to private telephone companies are now permitted to extend their communications through any of the public offices upon payment of an annual tax of 40 francs per annum in Paris, and 30 francs per annum in the provinces.

THE "PYLADES."—The Admiralty have decided to arm the "Pylades" with 14 5-in. steel long range breechloading guns, mounted on the Vavasseur system of carriages. She is fitted with the electrical machinery for discharging the spar torpedoes, and when completed for active service she will be the strongest vessel of her class afloat.

THE ELECTRIC LIGHT IN THE LEEDS MUNICIPAL BUILDINGS.—We understand that, to avoid further litigation, the contractors have offered to make certain changes in this installation, an offer which has been accepted by the Corporation as very satisfactory. The electric light will therefore be at work again in two or three weeks' time.

EXTENSION OF THE INDIAN TELEGRAPH SYSTEM.—A telegram, dated Allahabad, Wednesday night, says so much inconvenience was experienced by the Indian Government during the recent agitated period in obtaining information beyond the Indo-Afghan frontier, that it is being seriously advocated that the Indian telegraph system shall be extended to Candahar and Herat.

AN INTERESTING EXCURSION.—On Saturday the Royal Historical and Archæological Association of Ireland brought its annual meetings and excursions to a termination. During the proceedings interesting papers were read upon various subjects, and several excursions were made, one of which was to Dunluce electric generating station in connection with the electric tramway at River Bush, and the residence of Dr. Traill, F.T.C.D.

NOT PROGRESS.—A Daddsville woman is about to patent an electrical device having for its object the abolition of flirting in the conjugal domicile—that is to say, to prevent any flirting on the part of the husband during the absence of his better or worse half. This is not progress. We don't want things of this sort, and if our efforts on behalf of domestic lighting are to be only productive of ingratitude, the sooner we revert to chaos the better.

TRIAL OF AN INSTALLATION.—The official trial of the installation at Messrs. J. Bell and Sons, erected by the Electrical Power Storage Company, has just been completed. The conditions were that a proportion of the lights were to be supplied by the accumulators for sixteen hours; that the cells were to be recharged in eight hours, and were then to supply the lights for another sixteen hours. The dynamo was driven by means of countershafting from the air compressor engines, and the conditions of the trial were amply fulfilled throughout.

THUNDERSTORM IN LONDON.—On Wednesday evening, shortly after six o'clock, a thunderstorm, light at first, but gradually becoming violent, burst over the metropolis. The peals appeared at the outset to come from the eastward, but the later and louder ones burst forth from the south-east; and they were accompanied with very heavy showers of rain. The last peal of thunder was of extraordinary force and power, and literally shook the windows in many houses in the south-eastern district. Rain continued to fall until dusk, and the atmosphere appeared to be still charged with electricity.

ELECTRIC LIGHTING AT BUCKINGHAM PALACE.—At the last State ball the various rooms were lighted by electric light. The arrangement, which was carried out by the Electrical Power Storage Company, and which was on a larger scale than any previous attempt of the kind, was very successful, and gave

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much satisfaction. The total number of lamps fixed was 340, of which 280 were of 20 candle-power and 60 were of 10 candle-power. The whole current for the lamps was supplied from accumulators placed in a tent in the garden, the cells having been brought, ready charged, from the works of the company at Millwall.

CONCESSIONS TO INDIAN TELEGRAPH OFFICIALS.—It is notified that officers of the telegraph department who attain the rank of superintendent 4th grade, and serve in that rank for a period of three years, are eligible for the special additional pension of 1,000 rs. per annum admissible to directors of construction and traffic under paragraph 4 of the resolution of January 23 last. Officers whose cases Government was said to be prepared to consider favourably in paragraph 3 of the resolution will now be those who may attain to the rank of superintendent 1st grade. The orders will have effect from May 1 last.

TRANSMISSION OF POWER AT THE ANTWERP EXHIBITION.—Amongst the most interesting of the installations at the Antwerp Exhibition, that of the Compagnie Générale d'Electricité, for raising the sea water to supply the aquarium in the Belgian section, may be mentioned. This installation comprises two Gramme dynamos, the generating machine being placed in the Galerie des Machines, and the receiver near the aquarium. The water is elevated to a height of 7 metres. The same generator also actuates a second dynamo situated at the exhibit of the Société l'Electro-Métallurgique de Geneve, at the opposite end of the Galerie des Machines.

CONSOLIDATION OF ELECTRIC LIGHTING COMPANIES IN AMERICA.—The consolidation of the Brush, the New England Weston, and the Merchants' Electric Light Companies of Boston was effected July 11. The new company is to be named the Union Electric Light and Power Company, and will have a capital stock of $700,000. Of this the Brush Company receives $250,000, each of the other $225,000. The consolidated company will assume the debts of the old companies, putting them into fifteen-year bonds. The lighting capacity of the three united companies is 1,900 lights, with steam-power at the stations sufficient for 500 lights additional.

THE ELECTRIC LIGHT IN TURIN.—The Municipal Council of Turin have finally decided to light certain streets in the town by electricity. The installation, which will be completed and in working order by the 1st of January, 1886, will be divided into two sections. In the first of these the lamps will be supplied direct from the dynamos; but in the other the secondary generators of Gaulard and Gibbs will be employed. The lamps will be arcs of from 800 to 5,000 candle-power and incandescents of 50 candle-power. The cost of the lighting is estimated at about £5,200 per annum, whilst the cost of gas lighting is only £3,200. There will, however, be a total increase of more than 70,000 candles over the present system, or about eight times the light now afforded by gas.

THE EARTHQUAKES.—A Reuter's telegram, dated St. Petersburg, Aug. 3, says:—Despatches from Tashkend and Verny announce that there has been a severe earthquake at Pishpek (? Bish-uzek), damaging all the houses at that place. The shock extended to the settlements of Sukuluk and Belovodsk, which were laid in ruins. At Belovodsk a church fell in, many of the congregation assembled in it at the time being killed. Numerous fissures appeared in the ground. A later telegram from Verny reports that altogether fifty-four people were killed and sixty-four injured by the earthquake at Belovodsk and Karabolty. The shocks continue, and the people are terror-stricken. The earthquakes in Spain continue to occur. A telegram from Malaga states that a shock occurred at Motril on the afternoon of the 30th ult.

THE RUSSIAN TELEGRAPHS IN CENTRAL ASIA.—St. Petersburg is connected with Bami, between Kizil Arvat and Askabad, by two separate lines of telegraph. A cable laid in the Caspian joins the Russian telegraph network at Baku to Krasnovodsk, which is in communication with Bami by a land line passing through Michaelovski and Kizil Arvat. On the other hand, the Russian telegraph line is connected with the Persian at Julfa on the Arax, whence, passing *viâ* Tabreez and Teheran, it is rejoined to the Russian wire on the frontier of Askabad, and thence is continued through Tchikislar to Bami. From here a single line is carried to Askabad, the place of residence of the Governor of the Transcaspian province, and thence latterly to Merv and Sarakhs. Thus the Russians are in comunication by two separate telegraph lines with their lately acquired and outlying province in Central Asia.

THE LIPPMANN GALVANOMETER.—A mercury manometer is placed between the poles of a fixed magnet, which lie right and left of its horizontal arm. The current traverses the latter in a vertical direction parallel to the axis of the tube, by which the mercury rises in one limb. If i is the strength of the current, H the strength of the magnetic field, l the length of a small rectangular parallelopipedon in the direction of the current, ϵ its thickness in the direction of the lines of force, the force which displaces the parallelopipedon is Hli, and the pressure $p = \frac{Hli}{l\epsilon} = \frac{Hi}{\epsilon}$. Hence the sensitiveness increases with the strength of the magnetic field and the thinness of the column of mercury. Accordingly the lower bend of the manometer is replaced by a chamber filled with mercury at right angles to the current, and only $\frac{1}{10}$ millim. in thickness.

THE ELECTRIC LIGHT IN BALLYMENA.—A trial of the electric light was recently made at the end of Harryville Bridge and Waveney-road, Ballymena, where one of the Belfast arc lamps was raised by the Belfast Electric Light Appliance Company, and the electric light produced under the superintendence of Mr. W. H. Drennan. The driving power was supplied at the Braid Water Foundry, and the dynamo machine was one of Newton's patent. The light, which was said to be equal to about 2,000 candle-power, was exceedingly brilliant, and whilst it illuminated portions of the town for a considerable distance in various directions it was witnessed by thousands of spectators who congregated in the streets. The introduction of the light to Ballymena was freely discussed among the assemblage, and many appeared in favour of the project, whilst others shook their heads in doubt and dissent. Later a portion of the town was lighted up with incandescent lamps.

MR. GLADSTONE AND ELECTRICITY.—On the occasion of his recent visit to the International Inventions Exhibition Mr. Gladstone remained for some time in Sir Francis Bolton's chamber in the tower. Mr., Mrs., and Miss Gladstone tried their hands at directing the illuminations of the fountains by touching several keys, which brought forth certain colours in the water display. Mr. Gladstone made some pretty contrasts, but Miss Gladstone's combinations of colours were most satisfactory. Mr. Gladstone had the several plans of electric lighting of the gardens explained to him, and there was not a little fear lest he should by some mistake touch the wrong key and switch off the lights and leave the whole of the gardens in darkness. The fountains display gave the whole party great interest, and after spending over 20 minutes in Sir Francis Bolton's machinery room, a move was made to Old London, where the party remained some time, admiring

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the workmanship, the electric machinery room, and the grand entrance gallery.

CITY AND GUILDS OF LONDON INSTITUTE.—The report of the seventh annual examination in technology, which took place in May last under the direction of this institute, has been issued. The number of candidates examined, 3,968, was more by over 300 than in the previous year, while the number of passes increased from 1,829 to 2,168. Two new subjects, boot and shoe manufacture and framework knitting, were last year added to the list of subjects in which examinations are held. The percentage of failures on the results of the examination in all subjects decreased from 49·7 in 1884 to 45·3 in 1885. This, the report states, is still a very large proportion, showing the necessity of better instruction on the part of the teachers, and of more careful and sustained work on the part of the students. This year Manchester heads the list of provincial centres from which the largest number of students have passed, and it may be added that during the year 6,396 persons have received technical instruction in connection with these examinations, at a cost per student of less than 11s. for the session.

ELECTRICITY AT THE MECHANICAL ENGINEERS' MEETING, LINCOLN.—At the opening meeting, on Tuesday last, during the discussion on Mr. Ruston's paper on the Dunbar and Ruston Steam Navvy, Mr. Sydney Walker expressed the opinion that it might be worked by electrical current transmitted from a fixed and permanent source of supply; and Mr. Ruston replied that if power could be transmitted by electricity, so as to be more economical than steam, he would be glad to adopt it. In a paper on recent adaptations of the Robey semi-portable engine, Mr. John Richardson observed that this engine is admirably suited for electric lighting, being fitted with an electric speed regulator instead of the ordinary centrifugal governor. One of its incidental advantages, particularly in connection with compound engines, in which any wide variation in the duty results in loss, is that with its aid such an engine may be made to develop 5 horse-power as economically as 50 horse-power, while making the same number of revolutions per minute. This governor is fully described in Mr. R. H. C. Nevile's paper on private installations of electric lighting, read on the following day, which is commenced in our present issue.

SMALL CONTRIBUTIONS THANKFULLY ——.—The *New York World*, in its wonderful feat of collecting its 96,000 dollars from 100,000 patriotic Americans, has given evidence of the power and influence of the Press, and also of the willingness of the American people at large to respond to any call upon their patriotism. There remain yet a few thousands to be subscribed to the Pedestal Fund. The *Newark* (U.S.A.) *Journal* has on exhibition at its office an exact reproduction of Bartholdi's great work, in bronze, which stands upon a handsome mahogany case, containing an electric attachment. When a quarter of a dollar is dropped into the aperture at the base of the statue a "cam" inside revolves, depositing the coin in a locked draw below. At the same moment the cam presses a spring, which completes an electric circuit between a set of Bunsen cells beneath, and a small Edison incandescent lamp, which Miss Liberty holds aloft in lieu of a torch. The torch flashes its tiny light for a moment at every coin that enters the drawer. The apparatus is so adjusted as to operate only with a quarter of a dollar, but, a contemporary considerately adds, those desiring to put in larger contributions can drop them in in quarters.

THE SALTERS' COMPANY AND TECHNICAL EDUCATION.—The following resolution was passed at a meeting of the Court of the Salters' Company, held on July 31, 1885:—"That the Court of the Salters' Company being informed of the need of increased funds to enable the City and Guilds of London Institute to maintain in efficiency the various branches of work for the advancement of technical education to which the confederated companies are pledged, hereby agrees to raise its annual subscription to the institute from £525 to £1,000, payable in moieties during the pleasure of the court in the months of May and November, and that the Right Hon. the Lord Mayor, as Master, be requested to signify the same to the late Lord Chancellor Selborne, and Sir Frederick Bramwell, vice-presidents, chairman of the Council and chairman of the Executive Committee respectively, adding an expression of the gratitude which the Salters' Company feel for the signal services which they have rendered to the interests of technical education, and of the Livery Companies in helping and directing the combined efforts of the City and Guilds of London in associating art and science with the furtherance of industrial progress."

THE MUTHEL INCANDESCENT LAMP.—Mr. Max Muthel's incandescent lamp requires no vacuum in the globe. He has also very ingeniously overcome the fusion of the incandescent wire. The wire used by him consists of a mixture of bodies that are conductors and non-conductors of electricity. He takes magnesia, silicate of magnesia, &c., and porcelain clay, and forms a fine thread of them, which he heats to incandescence and saturates with a solution of platino-iridium salts, and afterwards raises several times to incandescence in order to reduce the absorbed salts to a metallic state. Instead of the foregoing mixture, filaments of clay may be taken and saturated with a solution of a metallic salt, which is then reduced to a metallic state through incandescence and the use of oil of lavender or some other organic substance, or through an electric current. With wires thus prepared fusion is absolutely overcome, the presence of the non-conducting substances preventing the metallic parts from melting. Mr. Muthel supposes that the electric spark jumps, so to speak, from one particle to another, and in this way causes a heating of the other substances, which, brought to incandescence, emit a more intense light. In order to make the filaments stronger, they may be covered with chrome, the melting point of which is still higher than that of platinum. To effect this, the filament is placed as the anode in a bath of chloride of chromium.

COMMUNICATION WITH AFGHANISTAN.—An Allahabad paper thinks that the answer to the telegraph extension in the Herat direction should be the laying of the wire from Jamrud to Cabul. Abdul Rahman's authority is so fully recognised by the tribesmen along the route that working parties would, it is said, be safe from molestation if guarded by a small Afghan escort, and once the wire was laid it would probably be left intact if the various local headmen were made responsible to the Ameer for its safety. The Afghan traders who visit India use the telegraph freely, and they would not be slow to welcome it in their own country. Thus it would serve both political and trade purposes, and would exert a civilising influence in Northern Afghanistan. Cabul is only 160 miles from our frontier, and couriers easily cover the distance in three days, but direct telegraphic communication between the Ameer and the Government of India is highly necessary, as even a few days' delay might in the near future be of serious moment. Our alliance with Afghanistan is patent now, after the Rawul Pindi durbar, to all the world; and another outward and visible sign of its existence, in the shape of a telegraph line to Cabul, would not offend the delicate susceptibilities of Abdul Rahman's subjects. That the line should be made without delay is the opinion

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certainly of the majority of those who are best acquainted with the complex Central Asian Question.

THE INTERNATIONAL TELEGRAPH CONFERENCE AT BERLIN.—The opening sitting of the International Telegraph Conference has, with the Emperor's sanction, been fixed to take place at noon on the 10th inst. The chief matter to be dealt with by the Conference on the opening day will be a proposal on the part of Germany for the introduction of an international European tariff of a reduced and uniform kind. For the European network of telegraphs Germany proposes that this tariff should be fixed at 20 centimes a word, with a telegram tax of 50 centimes, while for those messages that have to pass over a submarine cable a supplementary *maximum* tax of 10 centimes a word might be charged. Such is the proposal with regard to conterminous countries, while extra transit dues on messages to "nonlimitrophe" countries, such as Belgium, Bosnia and Herzegovina, Bulgaria, Denmark, Greece, Luxemburg, Montenegro, Norway, the Netherlands, Portugal, Roumania, Servia, and Switzerland would be imposed at the rate of two centimes a word, and four centimes a word for Germany, Austria, Spain, Franco, Great Britain, Italy, Russia, Sweden, and Turkey. On cablegrams for distances under 300 nautical miles five centimes a word would be charged, and for greater distances 10 centimes. Conterminous countries might agree if they liked to reduce the tariff from 20 centimes to 10 centimes a word. MM. Frebourg, Lorin, and Brunot, the three delegates sent by France to the Congress, left Paris on Tuesday evening. The Post Office telegraph authorities of this country will be represented by Messrs. C. H. B. Patey, Secretary; H. C. Fischer, Controller of the Central Station; and Benton, of the Receiver and Accountant General's Office.

TELEGRAPHIC ADDRESSES.—A correspondent of *The Times* writes on the 6th instant as follows:—"Some months since you allowed me to offer to your readers some suggestions as to the simplification of telegraphic addresses, *à propos* of the sixpenny telegrams. They apply now in full force to the measure as accepted by the House of Commons, and it occurs to me that as a re-naming of streets and proper numeration will be a long affair, a simple method would be the numbering of all the streets, places, squares, &c., with progressive numbers. A small directory with the streets alphabetically arranged and opposed by consecutive numbers will give any address in a single group of figures of at most five characters, and the absurd custom of giving high-soundings names to individual houses would in most cases give place to numbers, so that the address might be simply given in three words—thus, Brown, 25, 5,672. The telegraph clerk, turning to this directory, will be able to write the name of the street from it instead of the number in the telegram. For the convenience of the telegraphic operators the telegraphic station which serves the street might be indicated by a letter or combination of letters in the directory. The sender of a telegram who had not provided himself with a copy of the directory would find at each station a copy from which he would get the number of the street he wishes to address to and fill it into his form, the address standing, when complete, thus, Brown, 25, 5,672 *ah*, the *ah* standing for the number of the telegraph station; or this may be given, if no confusion is likely, in plain numbers, but, being only for the guidance of the operator, should not be charged for or added to the address sent out. In this case the address would stand, Brown, 25, 5,672, 34. This leaves seven words for the message, which, supposing the *minimum* to be ten words, is very liberal. This need not prevent the rational designation of the streets of London, which would, however, be a longer process, and does not depend on the Post Office."

ELECTRICITY FOR STREET CARS.—A successful test and demonstration of the electric storage battery as a motive power for city passenger railways was made recently in America on the Union Passenger Railway from the stables on Huntingdon Avenue to Hampden, Baltimore County, and return. Eighteen persons were in the car, which, with the weight of the car, motor, &c., made a total of 5½ tons. The car moved out of the yard, passing over grades of 235ft. to the mile and around curves with 75ft. radius with ease and comfort. The batteries used on the occasion were simply the ¼ horse-power, not even made for motive power, but for incandescent light. Mr. Bauer, the electrician, however, after figuring out the subject, decided that even with these small boxes a street car could be run, as was fully demonstrated. Forty-nine of the little ¼ horse-power boxes were placed in the car and connected with the Daft electric motor. On level grades only 29 of these boxes were used, the loaded car making easily six miles an hour. On the 235ft. grade the 49 boxes were used, equal to $8\frac{4}{10}$ horse-power. A storage battery especially constructed for street-car purposes would consist of one hor e-power boxes instead of one-quarter, and about 65 would be required. The Storage Company on the day of trial placed their small boxes in the motor car used by the Daft Company. In practical usage these boxes will be put under the seats of the ordinary passenger car. The car will be started or stopped by simply turning a switch. An ordinary hand-brake was used, though this in future will be done by electricity. The first advent of the storage battery in America was on the steamship "Labrador," in November, 1882, at which time the rights under the patents for Maryland, District of Columbia and West Virginia, were purchased by Mr. A. G. Davis. The factory of that gentleman, the Viaduct, is said to be the only concern in America which has made experiments and finally demonstrated the practical use of the storage battery. The Storage Company propose at once to arrange the storage batteries for a street-car such as is used by President Bowie's City Passenger Railway Company. When they are complete the car will be put on the tracks and run through the city from one end to the other.

THE ELECTRIC LIGHT IN MINES.—An experiment is being made by the Low Moor Coal and Iron Company to supply electric light in their mines, with a view to reducing the risk of explosion, and at the same time give a better light in their workings. The pit selected for this experiment is that known as the Lofthouse, near Wyke Station, and is a black bed working well known to our local geologists. At the bottom of the shaft a main hauling path runs to the end of the pit some hundred and eighty yards, while parallel with this another road is cut for the same length, and turning at the end at right angles for a distance of one hundred and forty yards. At right angles with these roads the working faces of the pit are reached by cuttings at a distance of about sixty yards. Along the whole of the main roads incandescent lamps are fixed, while the workings are supplied with similar lamps, but in this case the lamps are made portable by allowing sufficient slack connecting wire to enable the miners to move them as required. These portable lamps are further supplied with a switch, to enable the miner on leaving his work to turn off the light. The electricity is generated by means of a Blakey-Emmott compound wound dynamo, capable of reducing from 60 to one light without alteration of speed. On Thursday week the mine was visited by Mr. Lawrence Hardy, J.P., of the Low Moor Company, and the company's engineer, Mr. Woodhead, together with Mr. Walter Emmott, the consulting electrician to the Crossley Telephone Company, of Albany-buildings, Bradford, under whose superintendence the

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lights have been fixed. Numerous experiments were made, showing the advantages of the electric light over the present form of Davy lamp employed. In point of illumination there was no comparison, as the main roadways were lit from end to end, to use the words of one of the men, "as well as any street," while the light at the working faces was even more noticeable, being distributed over a smaller area. The main point left for consideration seems to be the relative cost of the electric light and the old form of illumination, and if the former can be brought in at anything like a reasonable price, although it may be a considerable increase on the latter, we have no doubt the system will be adopted, as the loss of life and money due to an accident is a considerable item to be taken into account, and it is satisfactory to note that the Low Moor Company are the first to make the experiment in this district.

THE BLACKPOOL ELECTRIC RAILWAY.—New notoriety, says the *Blackpool Times*, will be given to this latest developed of the various Blackpool enterprises, by the refusal of the Government inspector to pass the lines laid by the Corporation. On Monday, from an early hour in the morning, crowds hung about the little piece of line running from the Foxhall down to the engine house and car sheds belonging to the Tramway Company. The reason was that there were indications of some experiments likely to be made by Mr. Holroyd Smith, the engineer for the electrical portion of the lines. The sightseers were not disappointed. Shortly before eight Mr. Smith came out with one of the cars, and ran several journeys over the short section of line mentioned above. The engine house is an extensive erection. In an apartment some 40ft. long by 28ft. wide, are two semi-portable engines, made by the celebrated firm of Marshall's, of Gainsborough. These engines are each capable of developing a power equal to 75 horses, and running at a very high rate of speed. The engines are of patent compound high pressure type, and are fitted with expansion gear. Their purpose is to drive three dynamos, two of which have been specially made for the tramway company, and they are said to be the largest in the world. They are made on the principle of Elwell and Parker's patents, with sundry modifications which Mr. Smith suggested to the patentees. These dynamos can be driven with one or both engines, as the occasion may demand. The shafting and gearing are both very ingenious, and the appliances which have been brought to bear for the obviating of possible difficulties, such as the breakdown of an engine, or the inability of a dynamo to perform its duty, are indicative of forethought and skill. Adjoining the engine house is the car shed, an erection of imposing dimensions, with a capability of housing at least a score of cars. There were nine in on Monday morning, some of which are very fine specimens of their order. These cars have been made for the company by Starbuck, of Birkenhead, and by the Lancaster Waggon Company. They are very beautifully made. If the line is not a success it will be no fault of the company, or of its engineer. Our only hope is that ere the season draws to a close they will have some chance to demonstrate to the public at large how important a scheme they have devised, and how completely they have carried it to a successful issue. We may mention that the car at the International Inventions Exhibition is one of ten built for the Electric Tramway Company of Blackpool. The generators now being fixed there will be capable of driving twice that number—sufficient, indeed, to carry 800 to 1,000 passengers. The line is over two miles in length, and will be shortly opened.

ELECTRIC LIGHTING IN MINES.—The following letter appeared recently in *The Times*:—"As I have been engaged for the past nine years in introducing electricity into the practical working of mines, and have, I believe, a closer acquaintance with them than any electrical engineer, or any one not actually engaged in their working can have, perhaps you will kindly afford me space to state my views on this subject. In the first place I would most strongly deprecate any suggestion of compulsory legislation, both as unjust to colliery owners, and unwise in the truest interests of the electric lighting industry. In my experience, no body of industrial proprietors are more ready to give a fair trial to a new apparatus, once it can be shown by practical work that it is for their advantage, and, on the other hand, it would be manifestly unfair to compel the adoption of an illuminant that might not be all that they require. For there are grave practical difficulties in the way of the use of the electric light at the working face, where it would be of most service, both from the additional light given and from the greater need of a safety lamp at that point. The working face is constantly moving, in one method of working ever receding, and the operation of getting the coal in its most marketable form entails the constant falling or shattering of huge masses, so that no fixed lamp would be of the least service or could live long. On the other hand, up to the present, so far as I am aware, no portable electric lamp has yet been produced which is of a reasonable weight and size, so that the collier can handle it and place it in position where his light is most required, and at the same time that gives a good light for the time required. By reducing the amount of light on the one hand, and its duration on the other, a few so-called mining electric lamps have been produced, but they would be useless for practical mining work, as they only last a few hours at the outside, while their cost is out of all proportion to that of the existing forms of lamp. In my opinion, the outcome of electric lighting in mines for the working face will be that supply mains will be led to convenient points near, and the collier will attach a pair of small wires to them and his lamp to the other end of his small wires and use it as he likes. Our strongest card in this direction is the rapid advances that are being made in the acquisition of the rudiments of electric science in every grade of society. I feel confident that as soon as the working collier realises the fact that he can have a good, powerful light, which he can manipulate as he pleases, by merely attaching two wires as I have suggested, and that the maintenance of the light and the continuance of his work depend upon the lamp and wires being kept out of harm's way, it may safely be left to him without fear of the result. If the electric light and other forms of electrical energy are to be utilised, as we hope, in mines, factories, and our homes, it will only be after having won their way in a fair field, and not under the wing of any grandmotherly legislation. The early progress of new inventions, more particularly electrical, is too often seriously retarded by inefficiency, arising from their promoters either not knowing or not fully appreciating the difficulties they have to contend with; and in my opinion compulsory legislation would greatly increase the chances of such inefficiency, with the result that the law would either be repealed or become a dead letter. Judging from the past, I think we need have no fear but that the electric light will make its own way in mines without extraneous assistance.—Yours very truly, SYDNEY F. WALKER, 195, Severn-road, Cardiff. P.S.—You are doubtless aware that several collieries already have their shaft bottoms and main roads lighted. We have already had two underground installations, working for two and a-half years and 18 months respectively, and are about fixing a third in a colliery belonging to the same firm who have had the installation running 18 months."

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 172.)

Electrization and Electrification. Natural Electrets.

A dielectric, not including ether, the universal medium, when under the influence of electric force, may be said to become electrized. We must not say electrified, as that refers to something entirely different from electrization, namely, electrification, or discontinuity in the displacement. The proper measure of the intensity of electrization will appear presently; in the meantime we need only observe that electrization is the analogue of magnetization, and, like it, requires the presence of matter.

Electrization may be approximately perfectly elastic with reference to the standard zero state, as in a dielectric in which absorption does not occur, so as to disappear on the removal of the exciting cause. This must be an impressed electric force somewhere, except in a transient inductive state, when there may be none, unless we choose to consider the electric force of induction as impressed; or else there must be electrification somewhere. There may also be residual electrization, namely, when absorption occurs. This may tend naturally to wholly subside, or a part of it may remain. The body is then permanently electrized. But, apart from artificial production of permanent electrization, it exists naturally in pyro-electric crystals, if nowhere else.

A word is evidently wanted to describe a body which is naturally permanently electrized by internal causes. Noticing that "magnet" is got from "magnetism" by curtailment at the third joint from the end, it is suggested that we may get what we want by performing the same operation upon electricity. An "electric," which is what results, would be a very good name for an intrinsically electrized body, but for two reasons. First, it was once used to signify what we should now call a dielectric or an insulator; and secondly, electric is now used as an adjective, or, equivalently, electrical. The former of these objections is of hardly any weight, that use of the word as a substantive being wholly obsolete. The latter is heavier, but still of no great importance. Another word that suggests itself is electret, against which there is nothing to be said except that it sounds strange. That is, however, a mere question of habit. Choosing, at least provisionally, the second word suggested, to avoid collision with the adjective, we may then say that certain crystals, if no other bodies, are natural electrets; that solid insulating substances may be made electrets artificially, with a greater or less amount of permanency; that liquid insulators can only be electrets for a minute interval of time, if at all; whilst gases, whose particles are always vigorously wandering about, are never electrets. But all insulators can be electrized; they are only electrets when the electrization, or part of it, is intrinsic.

Let J be the intensity of intrinsic electrization anywhere, and let $J = ce/4\pi$, c being the specific capacity at the place. Then e is the intrinsic electric force, and the displacement D and actual electric force E are determinable fully by the conditions

$$D = cE/4\pi; \qquad \text{div.}D = \rho; \qquad \text{curl}(e - E) = 0;$$

supposing that there is no conductivity. Here ρ is the volume density of electrification, if there be any. Should there be conductors present, charged or uncharged, their effect is determinable by the additional conditions of there being no force in any conductor (unless there be impressed force therein), and every separate conductor to have a given total charge, zero or finite, according as the conductor is not or is electrified when placed by itself in a space previously free from electric force.

The physical explanation of electrization is of course matter of speculation, as it depends not only on the nature of molecules, but also on their relation to the ether. Weber's theory of induced magnetization obviously suggests its analogue. Accordingly, we might say that the molecules of a body are always permanent electrets; but should there be, in a very small portion of it, but still large enough to contain a very great number of molecules, an average uniformity of distribution in all directions of their axes of electrization, there will be no external signs of its being electrized, or the intensity of electrization is zero. Next, the molecules admit of rotation, so that under the influence of externally caused electric force the axes of electrization are turned to a greater or less extent towards coincidence with the direction of the electrizing force. This preponderance of electrization in one direction of the molecules in our small volume naturally causes there to be a finite intensity of evident electrization or of electric moment. Should this angular displacement of molecules be only elastically resisted, the evident electrisation will wholly disappear on the removal of the electrizing force, or the body was only inductively electrized. Should there be a slow slipping, the phenomenon of absorption will occur, there being no longer a complete return of the molecules to their original state on removal of the electrizing force. The body is then made an electret. Should the slip be permanent, the body is an artificially made permanent electret.

Such a theory is of course very empirical, and admits of considerable variation according to the hypothesis we adopt regarding the angular displacement and its tendency to subside. There is of course a maximum intensity of electrization which cannot be exceeded, viz., when all molecules are turned the same way. It is only one way of accounting for evident electrization, and may be utterly unlike the reality. Weber's theory of rotation of molecules has a great many recommendations, but I do not think they go further than to make it anything better than a working hypothesis, even with the support of Professor Hughes's experiments.

But, admitting that molecules are electrets, we may go a step further, and, in a manner, account for it. In the first place the state of electric force and displacement determined by the above equations would be identically given in another manner. Do away with e, that is, do away with J, the intrinsic electrization, and substitute for it an arrangement of closed magnetic current of density $(-\text{curl}\, e)/4\pi = G$ say. The magnetic current G and the intrinsic electric force e are equivalent, so far as the distribution of displacement is concerned. In the case of a bar uniformly electrized longitudinally, the current G will be entirely superficial, going round the bar. But by Ampère's device, we may substitute a network of currents for a current bounding the network. Thus we may get down to the molecules, and ascribe their electrization to molecular magnetic currents whose moments equal their electric moments. But I do not put this forward as being at all a physical explanation of why molecules are electrets, if they be. There is merely a mathematical equivalence.

Nor do I, in the parallel case of explaining the magnetism of a molecule by means of a molecular electric current, admit that any step towards a physical explanation of magnetism has been made. Not that I attach much importance to the common objection originating from the fact that an electric current in a conductor requires a continual supply of energy to keep it up, owing to the Joule heating that goes on. For we observe the effects of heat in mass, and ascribe heat to the kinetic energy of agitation of the molecules. Not of the parts of molecules, but of their wholes. Now, considering a molecule as an atom, for simplicity, if an atomic current generated heat as a current in a wire does, the heat would be the energy of agitation of the parts of the atom, which, though indivisible, may yet not be of unchangeable form. This communication of energy would surely alter the nature of the atom. In fact it is assuming an atom to be like a body in the ordinary sense. In brief, conduction as we know it is an affair in which molecules or atoms as wholes are involved, so far as the heat is concerned, and it would be far more wonderful if atoms had internal resistance than, as we are obliged to suppose, that atoms are perfect conductors, if we choose to have atomic currents.

My reason for not considering a molecular electric current to be a physical explanation of magnetism is, that although the more closely we look at the matter, apart from old-fashioned notions of an electric current as something going round and round, the more we are led to the conclusion that the mag-

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netized molecule with its field of force and the Ampèrean current with its field of forces are really one and the same thing, yet we are brought no nearer to an understanding of either, so that explaining the former by the latter is futile, regarded physically. But let us return, for the present, to electrization.

Dismissing altogether all ideas concerning the possible electrization of single molecules, keep to evident electrization. To illustrate it with sufficient comprehensiveness, without any great complication, or difficult calculations, let the electrized body be of spherical shape, and let us perform a series of simple operations upon it.

(1.) Let there be a uniform field of electric force of strength E, and displacement D in air, of specific capacity c, practically equal to unity. Then bring into the field a perfectly neutral solid spherical dielectric of radius a and specific capacity c_1. Call those points on its surface where it is cut by a straight line through its centre parallel to the force of the undisturbed field the poles, the negative pole being that where the line of force enters, and the positive where it leaves the sphere. This line is the axis. Supposing c_1 greater than c, the lines of force will be drawn in by the sphere symmetrically with respect to the axis. The displacement is continuous, and is therefore made greater within the sphere than in the field previously. On the other hand the electric force within the sphere is weakened. Both are parallel to the axis and uniform, within the sphere. Let D_1 and E_1 be the displacement and force, then $D_1 = c_1E_1/4\pi$, and $D_1 = 3Dc_1/(2c+c_1)$. Thus it is not possible to make the displacement more than three times as great as before, and that is when $c_1 = \infty$. It is twice as great when $c_1 = 4c$. There is no real electrification, but the sphere appears electrified, to surface density D_1 at the positive pole, and elsewhere proportional to the sine of the latitude. The potential, not counting that of the undisturbed field, which increases uniformly parallel to the axis, is $\sigma r\cos\theta$ within and $\sigma a^3\cos\theta/r^2$ without the sphere, where $\sigma = E(c_1 - c)/(2c + c_1)$, at a point distant r from its centre, θ being the co-latitude. If the sphere be taken out of the field, its apparent electrification will disappear, unless absorption or conduction have occurred.

(2.) Whilst in the field, as above, let absorption occur, and go on until the displacement has become increased by D_2, such an amount as would be caused by an impressed force e_2 uniformly distributed parallel to the axis. We must not write $D_2 = c_1e_2/4\pi$; D_2 is less than this amount. For continuity in the displacement requires that when the displacement in the sphere increases from some cause in itself, there must be a corresponding change in the external displacement. The effect of the intrinsic electrization of intensity $J_2 = c_1e_2/4\pi$ is to make $D_2 = 2J_2/(2c + c_1)$ within the sphere. The apparent charge is increased in density to $(D_1 + D_2)\cos\theta$.

(3.) Next, remove the sphere from the original field of force. There is left the field due to the intrinsic electrization. The displacement within the sphere is D_2, and the apparent charge is of density $D_2\cos\theta$. The potential is $\rho r\cos\theta$ within and $\rho a^3\cos\theta/r^2$ without the sphere, where $\rho = c_1e_2/(2c + c_1)$. In fact the field is exactly similar to the magnetic field of a uniformly magnetised sphere. If the absorption gradually disappear, so will the external field.

(4.) But whilst the intrinsic electrization remains appreciably steady, let us cover the sphere with a metal coating, or in any other way produce surface conduction. There will be a current through the sphere from the negative to the positive side, and oppositely in the conducting coating. Thus the displacement within the sphere must be increased by the short circuiting; it becomes $D_3 = c_1e_2/4\pi = J_2$, the greatest displacement possible without external aid. The external field is done away with altogether. There is now a real distribution of electrification on the surface of the sphere, of density $-J_2\cos\theta$; *i.e.*, negative on the positive side and positive on the negative side. The potential is zero inside and outside. The electret is now in the state of the dielectric of a condenser in which absorption has occurred, and a first discharge taken, the remaining charge not being accompanied by difference of potential between the metal plates.

(5.) On removing the metal coating, the surface charge gives no signs of its presence.

(6.) Keeping the sphere insulated, let the intrinsic electrization subside. As it does so, an external field of the opposite character to before appears, the real surface electrification remaining constant, whilst the displacement it exactly neutralised becomes less. When the intrinsic electrization has gone, supposing it to wholly disappear, the displacement, inside and outside, is merely that due to the surface charge. Inside, the displacement is $+c_1J_2/(2c + c_1)$ and the potential is $-4\pi J_2r\cos\theta/(2c + c_1)$. Outside the potential is $-4\pi J_2a^3\cos\theta/r^2(2c + c_1)$. The apparent electrification has density $-2J_2r\cos\theta/(2c + c_1)$.

(7.) Finally we may get rid of the surface charge by again putting on the conducting coating, after which the sphere will be in its original neutral state.

The study of the theory of electrization is in some respects more important than of magnetization; on account of its greater generality it is more instructive. We have conductors and dielectrics, real and apparent electrification. The magnetic problems are less general on account of the absence of magnetic conductors, with corresponding absence of any magnetic representative of real electrification, as in (4) above, the magnetic matter or free magnetism being, except as regards a constant factor, the representative of the apparent or imaginary electricity, as in (3), where there was no real electrification.

As regards natural electrets, Sir W. Thomson's theory of pyro-electricity is (so far as is known to me) contained in a short article in "Nicol's Cyclopœdia," reprinted in Vol. I. of "Mathematical and Physical Papers," Art. 48, p. 315. Being only a few lines in length, I can scarcely be quite certain that, when fully developed, it would be exactly as I state it—that is to say, when details are gone into, similarly to the above—though, generally speaking, there is no room for ambiguity. A pyro electric crystal is a natural electret. In its neutral state, however, its external field of force has been done away with by surface conduction and convection. Disregarding eolotropy, it is then in the condition of the sphere in (5) above, the surface being charged so that its density equals the divergence of the internal displacement. Warming or cooling the electret, by altering the internal stresses, alters the intensity of electrization, whereby the surface charge no longer exactly balances it. If, for example, warming decreases the intensity of electrization, the positive end appears to acquire a negative charge, the negative end a positive, like the sphere (6) above. If it be kept at the higher temperature, and surface conduction occur, its surface charge will readjust itself to again balance the internal displacement. Evidently we cannot get rid of the surface charge as in (7), unless we can make the intensity of electrization zero.

The electret may, however, without change of temperature, produce external force by breaking it across its axis of electrization, when, evidently, the two pieces will not be neutral, unless the act of fracture should cause exactly the right amount of electrification on the fractured surfaces, which is highly improbable. But by surface conduction again the two pieces will each become neutral.

Thermodynamic principles have also been applied to the case by Sir W. Thomson, under date 1879. This is the easiest part of the matter, considered qualitatively, if we know exactly the influence of heat. Applying the principle of thermal resistance discussed in the last section, we see that moving a natural electret about in an electric field must cause thermal effects. If, for example, as above, heat decrease the intensity of electrization, by decreasing the capacity, if we suddenly put the electret in an electric field so as to increase the displacement, the increase must be resisted, and this requires the electret to be heated. If now, we suddenly invert it, so as to decrease the displacement, this decrease must be resisted, hence a cooling effect. Should e vary as well as c, the application will be more complex. The phenomenon is no doubt very insignificant, but is very curious when we consider that it must occur in neutral crystals showing no external signs of their electrization.

(To be continued.)

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ON THE USE OF DANIELL'S CELL AS A STANDARD OF ELECTROMOTIVE FORCE.*

BY J. A. FLEMING, M.A., D.SC. (LOND.).

The extensive use now being made of strong currents of electricity for purposes of illumination necessitates the employment of instruments for measuring current strength and electromotive force of high values. The employment of electricity for telegraphic purposes, and especially in submarine telegraphy, compelled attention to a common accuracy in measurement of resistance and capacity; but for these purposes the measurements of electromotive force and currents are not of such importance as they are in the recent developments. This requirement has drawn the attention of electro-mechanicians to the subject, and led to the inroduction of numerous forms of electromotive force and current indicators, variously called potential galvanometers, voltmeters, pressure gauges, ampere- or am-meters.

Considering first the voltmeters, they may be classified, according to Sir W. Thomson's nomenclature, into two classes —idiostatic and heterostatic. In the second class the magnetic force at a point in the neighbourhood of a conductor conveying a current is compared with another magnetic field either of the earth or of a permanent magnet, and the difference of potential at the ends of the conductor deduced therefrom. In the first class no magnetic field is made use of other than that created by the current itself.

In the case of heterostatic instruments the readings require to be controlled by a special determination of the value of the

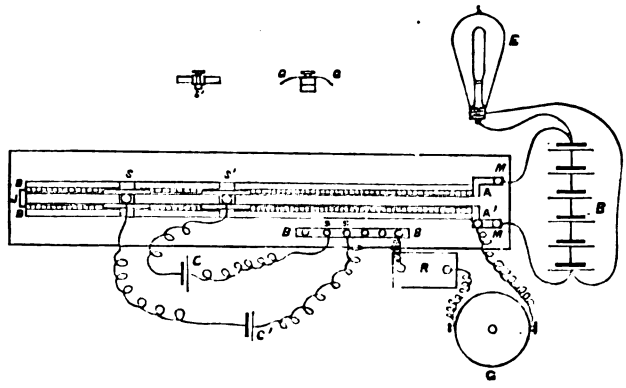

FIG. 1.

auxiliary field; and in the case of an ordinary tangent or sine-galvanometer, the determination of the earth's horizontal magnetic force is a task requiring great care and considerable precautions. In the idiostatic instruments, in many cases, springs are used to obtain a force with which to compare the magnetic force in the neighbourhood of a conductor. The elasticity of these springs is not necessarily permanent, and is liable to change by temperature as well as time. Accordingly in these instruments also the constant must from time to time be determined. Pending the appearance of the new instruments promised by Sir W. Thomson, in which no springs nor permanent magnets are used, it is necessary to fall back upon galvanic cells to establish a standard of electromotive force, and the present paper is a brief collection of facts concerning the use of Daniell's cell for this purpose, and its application in the measurement of currents of various strengths. In all the experiments and methods cited below the cell has been used only to create a difference of potential, and not allowed to send any but a very small current, the means employed for comparisons being a slight modification of Clark's potentiometer, as shown in Fig. 1. On a stout mahogany board are fastened down two boxwood scales, each 5ft. long, divided into inches and tenths; these scales are fixed about ¼in. apart and parallel, so as to form a groove between them. On these scales are stretched two fine uniform German silver wires A B, A′ B′, about ·013 inch in diameter, and having a resistance of about 1 ohm to the foot run; one end of both wires is soldered to a thick copper junction-piece, J, and the other ends respectively to copper pieces connected to terminals M M′. The wire thus forms one length of about 10 feet stretched over two scales. This forms the potentiometer wire; its length is divided by the scale into 1,200 parts, and each tenth of an inch can be divided by the eye into 10, making a possible division of 12,000. To the terminals M M′ are connected five or six large-gravity Daniell cells, and the poles of this battery are short-circuited by an Edison 16-candle lamp of 240 ohms cold resistance. This enables the battery to keep a more constant difference of potential between the terminals M M′.

A very constant E.M.F. can be obtained by using small accumulator cells in series, the poles being joined by a carbon filament lamp, and the leads to the terminals M M′ taken off from the opposite sides of the lamp.

It is easy to calculate what number of cells are required to maintain a given difference of potential, say 2 volts, at the extremities of the potentiometer-wire. For let n be the number of cells, e the E.M.F. of each, and r the internal resistance, and let R be the resistance of the lamp and potentiometer-wire combined, and v the required difference of potential desired at the terminals M, M′; then

$$v = \frac{ne\mathrm{R}}{nr + \mathrm{R}},$$

which determines n. If r is not known, it can be determined by a second experiment, in which v is observed in the case of a given number of cells.

The current along this German silver wire makes a fall in potential at about the rate of 1 volt in 5ft. On one side of the board is fastened a broad copper strap, b b, having six terminals fastened upon it. Between the last of these terminals and the end of the scale-wire A′ is inserted a reflecting-galvanometer of 5,000 ohms resistance, and an additional resistance of 50,000 ohms R.

To the other terminals, s, s on this copper strip are connected one pole (like to the pole of the battery B connected to M′) of each of the cells c, c' to be compared; and the other poles of these cells are connected with sliders S, S′ travelling over the wires. These sliders are blocks of wood sliding in the groove between the scales, and overhanging the wires. On them are German silver spring strips as shown in the figure, and which, when pressed down, make contact with the wire. The strips are backed with leather to avoid the production of thermo-electric currents. By using two or more of these sliders it is easily seen that several cells may be balanced at once on the potentiometer; and in particular two cells, $c\,c'$, can be compared in respect of electromotive force very accurately, even although the E.M.F. of the main battery is not quite constant. The introduction of the resistance R prevents any but the very smallest currents passing in the cells when the place of balance is being found on the potentiometer. The German silver strips $g\,g$ on the sliders make contact only when pressed down, so that in the normal condition the cells $c\,c'$ are insulated. With the galvanometer in a sensitive condition it is very easy to read a difference of $\frac{1}{10000}$ of a volt on the wire, and $\frac{1}{1000}$ can be read with great accuracy.

Electromotive forces are read out directly as lengths, since the E.M.F. of the cells $c\,c'$ is directly as the distance of the constant points of their respective sliders from the end A′ of the wire. Great care has to be taken in the first instance to stretch the wire uniformly, and to calibrate it if it presents any want of uniformity of resistance. Provided with this convenient means of directly comparing electromotive forces, attention was next directed to a modification of Daniell's cell suitable for the experiments required. In Dr. Alder Wright's extensive researches on the subject*, the form of cell employed was that sometimes called Raoult's form, in which two small beakers contain the two solutions, and are connected by an inverted Y-tube, the ends of which are tied over with thin bladder. This form of cell is undoubtedly convenient for

* From the *Phil. Mag.* for August (communicated by the Physical Society. Read June 27, 1885).

* "On the Determination of Chemical Affinity in Terms of Electromotive Force.—Part V. On the Relationships between the Electromotive Force of a Daniell Cell and the Chemical Affinities involved in its Action." *Proceedings* of the Physical Society of London, Vol. V., Part I., p. 44 *et seq.* [*Phil. Mag.*, Vol. XIII., p. 265].

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some purposes, but not for others, as when the cell has to be heated or cooled for comparison at different temperatures. Moreover, the siphon becomes filled in a very short time with a mixture of solutions by diffusion; and if the levels of the liquids are not exactly equal, a siphoning action is added to that of diffusion in carrying liquid over from one side to the other. After some numerous trials of all existing forms which have been proposed for Daniell's cell, a form was devised, which, though more bulky than others, has yet given great satisfaction, and has the great recommendation of always standing ready for use.

(To be continued.)

THE SUBMARINE TELEGRAPH CABLES BILL.

The following is the text of the Bill (as amended in committee) intituled "An Act to carry into effect an International Convention for the Protection of Submarine Telegraph Cables":—

1. This Act may be cited as the Submarine Telegraph Act, 1885.

2. The Convention of the fourteenth of March, one thousand eight hundred and eighty-four, mentioned in the schedule to this Act, as set forth in that schedule, is hereby confirmed, and subject to the provisions of this Act the articles of such Convention (referred to in this Act as the Convention) shall be of the same force as if they were enacted in the body of this Act.

3. (1.) A person shall not unlawfully and wilfully, or by culpable negligence, break or injure any submarine cable to which the Convention for the time being applies, in such manner as might interrupt or obstruct in whole or in part telegraphic communication.

(2.) Any person who acts or attempts to act in contravention of this section shall be guilty of a misdemeanour, and on conviction—

(*a.*) if he acted wilfully, shall be liable to penal servitude for a term not exceeding five years, or to imprisonment, with or without hard labour, for a term not exceeding two years and to a fine either in lieu of or in addition to such penal servitude or imprisonment; and

(*b.*) if he acted by culpable negligence, shall be liable to imprisonment for a term not exceeding three months, without hard labour, and to a fine not exceeding one hundred pounds either in lieu of or in addition to such imprisonment.

(3.) Where a person does not act with the object of preserving the life or limb of himself or of any other person, or of preserving the vessel to which he belongs or any other vessel, and takes all reasonable precautions to avoid injury to a submarine cable, such person shall not be deemed to have acted unlawfully and wilfully within the meaning of this section.

(4.) A person shall not be deemed to have unlawfully and wilfully broken or injured any submarine cable, where in the *bonâ fide* attempt to repair another submarine cable injury has been done to such first-mentioned cable, or the same has been broken; but this shall not apply so as to exempt such person from any liability under this Act, or otherwise to pay the cost of repairing such breakage or injury.

(5.) Any person who within or (being a subject of Her Majesty) without Her Majesty's dominions in any manner procures, counsels, aids, abets, or is accessory to the commission of any offence under this section, shall be guilty of a misdemeanour, and shall be liable to be tried and punished for the offence as if he had been guilty as a principal.

4. Article four of the schedule to this Act shall not apply to that part of a cable which is laid in a depth of water exceeding one hundred fathoms, but nothing in the Convention or this Act shall take away, prejudice, or affect any right or remedy to which by law any party is or may be entitled otherwise than under the provisions of the Convention or this Act.

5. (1.) It is hereby declared that the enactments of the Merchant Shipping Act, 1862, and the enactments amending the same, touching regulations as to lights and to signals and for the avoiding of collisions, shall extend to authorise regulations for carrying into effect Articles five and six of the schedule to this Act, within as well as without the territorial waters of Her Majesty's dominions, and regulations may be made, applied, altered, and revoked, and the contravention thereof punished accordingly under the said enactments, and section six of the Sea Fisheries Act, 1883, shall extend to the enforcement of the said regulations as regards sea fishing boats within the limits of that Act.

(2.) If any vessel engaged in the laying or repairing of a submarine cable to which the Convention for the time being applies, interferes contrary to the said regulations or articles with any vessel engaged in fishing, or if the operations of any vessel in connection with any such submarine cable are wilfully delayed so as to interfere with sea fishing, the master of the vessel, or the owner thereof, if it appear that he was in fault, shall be deemed guilty of a breach of the said regulations and may be punished accordingly.

6. (1.) For the purpose of carrying into effect the convention, a person commanding a ship of war of Her Majesty or of any foreign state for the time being bound by the Convention, or a ship specially commisioned for the purpose of the Convention by Her Majesty or by the government of such foreign State, may exercise and perform the powers and duties vested in and imposed on such officer by any article in the schedule to this Act.

(2.) If any person obstructs any such officer in such exercise or performance, or refuses or neglects to comply with any demand or direction lawfully made or given by him in pursuance of this Act, such person shall be liable, on summary conviction, to a fine not exceeding fifty pounds, or to be imprisoned for a term not exceeding two months, with or without hard labour.

(3.) Any action, prosecution, or proceeding against any officer for any act done in pursuance or execution or intended execution of this Act, or in respect of any alleged neglect or default in the execution of this Act, shall not lie or be instituted unless it is commenced within twelve months next after the act, neglect, or default complained of.

(4.) In any such action tender of amends before the action was commenced may, in lieu of or in addition to any other plea, be pleaded. If the action was commenced after such tender, or is proceeded with after payment into court of any money in satisfaction of the plaintiff's claim, and the plaintiff does not recover more than the sum tended or paid, he shall not recover any costs incurred after such tender or payment, and the defendants shall be entitled to costs, to be taxed as between solicitor and client, as from the time of such tender or payment.

(5.) Every such action shall be brought in one of Her Majesty's Superior Courts in the United Kingdom (which Courts shall have jurisdiction to try the same wherever the matter complained of occurred) or in a Supreme Court in India or in a Court exercising in a British possession the like authority as the High Court of Justice in England, but in no other Court whatsoever.

7. Part X. of the Merchant Shipping Act, 1854 (which relates to legal procedure), and the enactments amending the same, so far as unrepealed, shall have effect as if enacted in this Act, and offences under this Act may be tried, and fines under this Act recovered accordingly, save that nothing in the said part shall authorise the award of any punishment not authorised by this Act, or the summary prosecution of any indictable offence under this Act.

8. (1.) Any document drawn up in pursuance of Article seven or Article ten of the schedule to this Act shall be admissible in any proceeding, civil or criminal, as *primâ facie* evidence of the facts or matters therein stated.

(2.) If evidence contained in any such document was taken on oath in the presence of the person charged in such evidence, and such person had an opportunity of cross-examining the person giving such evidence and of making his reply to such evidence, the officer drawing up such document may certify the said facts, or any of them.

(3.) Any document or certificate in this section mentioned purporting to be signed by an officer authorised to act under the schedule to this Act for carrying into effect the Convention, shall be admissible in evidence without proof of such signature, and, if purporting to be signed by any other person, shall, if certified by any such officer to have been so signed, be deemed until the contrary is proved to have been signed by such other person.

(4.) If any person forges the signature of any such officer to any such document as above mentioned, or makes use of any such document knowing the signature thereto to be forged, such person shall be guilty of a misdemeanour and liable on summary conviction to imprisonment for a term not exceeding three months with or without hard labour, and on conviction on indictment to imprisonment with or without hard labour for a term not exceeding two years.

9. Where any offence against this Act has been committed by means of a vessel, or of any boat belonging to a vessel, the master of such vessel shall until some other person is shown to have been in charge of and navigating such vessel or boat, be deemed to have been in charge of and navigating the same, and be liable to be punished accordingly.

10. The provisions of this Act shall be in addition to and not in derogation of any other provisions existing at common law or under Act of Parliament or under the law of a British possession for the protection of submarine cables; and nothing in this Act shall prevent any person being liable under any Act of Parliament, law of a British possession, or otherwise to any indictment, proceeding, punishment, or penalty other than is provided for any offence by this Act, so that no person shall be punished twice for the same offence; and nothing in this Act, nor any proceedings with respect to any matter, shall exempt a person from any liability in any action or suit with reference to the same matter, so that no person shall be required to pay compensation twice in respect of the same injury.

11. This Act shall so far as such extension is consistent with the tenor of this Act extend to the whole of Her Majesty's dominions, and to all places within the jurisdiction of the Admiral of England, and to all places where Her Majesty has jurisdiction.

12. In this Act, unless the context otherwise requires,—

The expression "vessel" means every description of vessel used in navigation in whatever way it is propelled; and any reference to a vessel shall include a reference to a boat belonging to such vessel:

The expression "master" includes every person having command or charge of a vessel:

The expression "British possession" includes any part of Her Majesty's dominions exclusive of the United Kingdom:

The expression "person" includes a body of persons corporate or unincorporate.

13. This Act shall come into force on such day as may be fixed by a notice in that behalf published in the London Gazette, and if the Convention ceases to be binding on Her Majesty, shall cease to be of any effect.

DIAMOND COAL.—An almost incombustible coal, which stands between the graphite and the diamond, has recently been invented by a Swedish civil engineer, Mr. Westerlund, of Stockholm. The coal, we are informed, promises to be the best material for carbons used in arc lighting.

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THE HOUSE OF LORDS AND THE PROTECTION OF SUBMARINE CABLES.

The longer the Convention for the Protection of Submarine Cables is under discussion the more evident it becomes that submarine cables and their owners would have been much better off without it. When those twenty-six meddling and ill-informed plenipotentiaries signed the Convention of Paris last March, there was evidently no thought in their minds that the very next cable operation of any magnitude would render their decisions of non-effect, or of so extremely vexatious a character as to be intolerable to the parties concerned. And as regards the parties themselves, being perfectly well satisfied with the English law as it stood, and having no suspicion that a body of alien gentlemen sitting in a foreign capital could virtually recast the laws of this country, they treated the Convention with the utter indifference which the Convention had shown towards them.

But when it is found that in compliance with the terms of the Convention the British Legislature is asked to alter existing laws, and when, too, the alterations demanded are such as will place English cable property—or rather its proprietors—in a more precarious position than they were in before, the Companies have bestirred themselves to protest as best they can against a proceeding which, whether intended to do so or not, puts them at a disadvantage as compared with those enterprising competitors who, since the Convention was formulated, have laid fresh cables with deliberate disregard of the positions and routes of previously laid cables. There would be no need for frosh legislation, and the Paris Convention might have been allowed to pass unnoticed, had any authority existed in this country capable of protecting existing rights against being wantonly invaded and wilfully endangered. The Duke of Richmond, as we predicted he would, has seen fit to accept a modification of Articles II. and IV., the effect of which will be to enlighten British juries as to the intention of the British legislators if not of the Paris plenipotentiaries. The captain of a repairing ship will not be liable to five years' imprisonment for breaking somebody else's cable, purposely put in his way, while repairing his own. But there still remains the question of future cable laying—the question, namely, whether such operations are to be regulated or not, and to this question we now wish to devote a few words.

In justice to the Convention, it must be owned that its intentions were good. By Article III., the contracting parties are pledged to insist upon proper measures of safety being taken as regards the track of any new cable, the concession for landing which is being sought. The natural assumption of the plenipotentiaries was that England, like every other country, had some authority over its shores; and the Marquis of Tweeddale's amendment, requiring the proposed concession to be treated as a provisional order, liable to be criticised and opposed on good reason being shown, proceeded on a like assumption. But, according to the Duke of Richmond, there is no such authority or right of prohibition in this country; or at all events, if there is, it ought never to be exerted. It passes our comprehension to understand how Article III. comes to be in the Convention at all if the British Government, whose subjects are the owners of nine-tenths of all the cables, is not prepared to carry it out—that is to say to create the right to grant concessions (or withhold them) if such a right does not exist at present. The legislative enactments recommended under the Convention are based on governmental control in the respective countries concerned; and indeed the Convention itself is a conspicuous example of conjoint interference and organised regulation on the part of national representatives. Only in England, apparently, does the parochial system prevail in defiance of Conventions and common sense.

For what else can the Duke of Richmond mean by his objections to the reasonable demand that all applications for concessions to land international cables on these shores should be made public, as is the case with purely internal concerns, before being confirmed? It would appear that all manner of public departments have rights of jurisdiction over the shore, and that it would even be a great hardship to any private individual "to whom the foreshore belongs, that he should not be able to grant a concession to a cable company to land on his property without coming to Parliament and having the application treated as a provisional order." We refuse to believe that the right to land a foreign cable can be conferred by any private gentleman who claims—a very questionable claim at best—to own the foreshore. But if this right exists, we venture to assert that, had the fact been disclosed at Paris, Article III. would never have been drawn up, and we gravely suspect that the rest of the Articles would have taken quite a different shape.

But this was not all. The noble Duke had the strongest objection to render concessions subject to the conditions of a

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provisional order because, among other reasons, the proposal "is very much in favour of existing companies." We cannot credit the Duke of Richmond with this remarkable discovery. It must have been prompted by some understrapper at the Board of Trade who has surreptitiously assumed the mantle of the late President. Favour the existing companies! To be sure it does; whom else should it favour we would like to know? But favour or no favour, there are rights which ought to be respected, and which may not be set aside on the plea that to respect would be to favour them. It is urged that if such applications were made public the old companies might "endeavour to buy up" the new venture. Here we detect the mantle whose virtuous skirts are rent with indignation at thought of any competitive scheme being nipped in the bud. But on reflection the new President of the Board may see that if a competing conspiracy wants to be bought up it will not desire to conduct its preliminary operations in secresy; whilst if, on the other hand, it means to compete it will not be hindered doing so by conducting them above board. Anyway, the Paris Convention intended that the high contracting parties should insist upon certain conditions of safety to other cable property being fulfilled by parties applying for new concessions; and by the rejection of the Marquis of Tweeddale's amendment the present Act fails to carry out this wise and essential provision.

A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should esteem it a favour if you would correct an error in your mention of my lamps at the Inventions in your last week's Supplement. The arc lighting Kapp dynamo drives *8* Statter lamps, each taking a current of *9·5* amperes.

Thanking you in anticipation.—Yours, &c.,

J. G. STATTER.

4, Lion-terrace, Chelmsford, August 4th, 1885.

PRIVATE INSTALLATIONS OF ELECTRIC LIGHTING.*

BY RALPH H. C. NEVILE.

Having for many years desired to use the electric light for domestic lighting, the author could not see his way to doing so while arc lights, and those anything but perfect, were all that were commercially practicable. When, however, incandescent lights were introduced he determined to make the experiment as soon as possible. Happening to have a 6 h.-p. portable engine some ten years old, which he had been using for pumping and for driving a saw, he determined to try this for the purpose, although warned that in all probability difficulties would arise in respect of the governing, as proved to be the case, in consequence of the governor being one of the old-fashioned kind with heavy balls revolving at a slow speed. In the course of last summer he arranged with Messrs. Edmundson, of Westminster, to carry out the wiring of the house, and in the autumn obtained from them a Siemens SD 9 compound shunt-wound dynamo, and completed the installation sufficiently to judge of the merits of electricity *versus* gas, which had been the previous illuminant.

The total number of lamps in the house is 125, divided over some fifty rooms and offices. The maximum number of lamps hitherto required at one time for purposes other than those of experiment has been fifty. All the main wires within the house have been laid to admit of the full number being used, and even of an increase to 150 or 200. The engine and dynamo are stationed in a shed about 180 yards distant from the point where the overhead cables enter the house; in this shed also is the saw table, so that by removing the belt from the dynamo and substituting one to the countershaft of the saw the latter can be driven by the engine when it is not required for lighting. The dynamo is driven direct from the fly-wheel of the engine by a 4in. linked leather belt, which suits the purpose very well, there being no uneven places caused by lacing or other joint to cause any unsteadiness in the running of the dynamo. Owing to the centres of the dynamo pulley and fly-wheel shaft being necessarily somewhat close together, the belt has to be kept rather tight when required to transmit the whole power of the engine. This, however, has never yet been required except for experimental purposes.

The current generated is led from the dynamo to a set of switches, by which it can be distributed into five separate circuits. The first of these is the circuit exciting the field-magnets of the dynamo itself. The second circuit furnishes lights for the engine shed and the carpenters' shop adjoining. The third goes to a schoolhouse near. The fourth goes by an overhead cable to the house, a branch being taken off to light the stables. The fifth circuit goes to a board, on which are fixed 100 lamps for experimental purposes; and this circuit is also intended to furnish current to secondary batteries or accumulators, which the author hopes to introduce before very long. The switches distributing these currents are two-way, so that the current can either be sent out direct or can be passed previously through one of Ayrton and Perry's spring ammeters, whereby the amount of current in use on any one or more of these circuits can at any time be ascertained without causing any interruption in the light. The ammeter in use, being constructed to register up to only 20 amperes, has been provided with two shunts of thick German silver wire, so that by using one or other of these the reading on the ammeter is reduced to one-half or one-third of the total amount passing; in this way the total current of 60 amperes can be registered.

The current for use in the house is led from the dynamo room to the roof in an insulated cable of fourteen No. 16 wires (0·065in. thick), and is thence taken overhead through a bare cable of the same size, suspended on poles, to the point at which it enters the house, where it is connected to a larger cable of nineteen No. 14 wires (0·085in.) This cable has been provided in order to admit of a larger number of lamps being used in the house at some future time, without disturbing the wiring, &c., inside the house. It leads well into the middle of the house, giving off on its way smaller branches to light sections of rooms, and then connects to a smaller cable, which again is reduced to a still smaller one before reaching the far end of the house. These cables all give off smaller branches to light the various rooms both up and downstairs. At their junctions with the mains the branches are fitted with fusible cut-outs, so that, in the event of any short circuit occurring of sufficient magnitude to cause any undue heating of the branch, the fusible plug would go, and would cut off that section. Most of the switches used have also fusible plugs in them, and are of the quick-breaking type, so that they cannot be left in such a position as to form an arc.

The lamps used are mostly 100-volt 20 candle-power lamps of the Edison and Swan make; but in some cases two 50-volt 10-candle lamps placed in series are used, instead of one 20-candle lamp. This is principally the case in passages, which are thus better lighted by the greater diffusion of the light; and moreover it is never required to light one of these lamps without the other. In the chapel there is a hanging chandelier with twenty lamps, in which the current is conveyed to the lamps by the suspending wires; and the chandelier is so arranged that, for the purpose of replacing lamps which have failed, it can be raised or lowered without disturbing any connections. In most other cases the lamps have either been left simply attached to the ends of the wires, or have been fixed to the old gas brackets. In the author's private workshop are a few lamps attached to flexible wires, which are very convenient for placing in various positions for working, and especially for turning.

The installation was first used in November last, and everything worked very satisfactorily, with the exception of the governor, which proved utterly unsuitable, the inertia being so great that its position would remain the same for a very considerable variation of speed, so much so that, although an

* Paper read before the Institution of Mechanical Engineers, at Lincoln, on the 4th inst.

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adjustable resistance of considerable magnitude had been inserted in the circuit exciting the field magnets of the dynamo, it was found impossible, even with this, to control the electromotive force to the point required. Frequently, when resistance was inserted, thereby lessening the work done by the dynamo, the engine in consequence of the lightened load would increase its speed sufficiently to bring up the electromotive force to its old point. The consequence was that it was necessary to keep the steam pressure in the boiler almost absolutely constant, or rather to allow it so to vary in proportion to the load that it should keep the electromotive force constant. This was found exeedingly difficult in practice, and it was soon seen that it would be necessary to get some more efficient kind of governor. Having seen the working of Mr. Richardson's electrical regulator, and being much pleased with its principle of action and with its performance, the author decided to try it, and one was accordingly adapted to his engine. Although this old-fashioned type of engine does not lend itself very readily to the introduction of the necessary valve, the object was attained in a very efficient though possibly rather unsightly manner, by taking the steam from the top of the safety-valve fitting, and passing it through the throttle valve actuated by the governor, and thence downwards into the steam-chest.

The regulating part of this governor consists of a double solenoid magnet, placed vertically and wound with insulated copper wire, within which works a double core; and to the crosspiece at the bottom of the cores is linked the long arm of a lever, the short arm of which presses upon the spindle of a double-beat Cornish valve that controls the admission of the steam to the steam-chest. For incandescent lighting in parallel, the wire on bobbins is placed in shunt circuit between the main leads; and the size of wire used is adjusted according to the electromotive force which it is desired to maintain between the mains, so that when the electromotive force is at the right point the cores are suspended within the solenoids by their attraction. Inasmuch as the resistance of the solenoids is fixed, any increase in electromotive force causes an increased current to flow through them, whereby the cores are immediately attracted with an increased force, and are caused to move upwards, thereby acting through the lever to close the valve until the electromotive force has been brought down again to its normal amount. The required movement of the valve is exceedingly small; and this method appears to be the best suited for electric lighting. An automatic expansion-gear, on which the governor might be caused to act, has the disadvantage that, when but a few lights are burning, the steam is cut off at so early a period of the stroke that unless the fly-wheel is exceedingly heavy a fluctuation occurs in the light during each revolution of the fly-wheel, somewhat analogous, though of course in a much smaller degree, to the unpleasant bobbing generally seen in electric lights driven by a gas engine where there are no accumulators. In a large engine, where economy of coal has to be considered, probably the best way would be to have an expansion gear actuated by hand, which can be set approximately to the expansion required, leaving the throttle-valve to regulate the speed finally. But where perfect steadiness is desired, it is probably better not to cut off much before half stroke, especially if a single-cylinder engine is used. The use of accumulators as regulators would of course prevent a great deal of the fluctuation, and would permit of the steam being cut off much earlier without causing any apparent unsteadiness the light.

The electric governor was fixed on the engine and worked for the first time on 13th January last. The improvement was remarkable, the lights remaining steady without the sudden alternations of brightness and dulness which had occurred before. But it was still found that with any considerable variation of boiler pressure or of load the electromotive force in the mains varied more than was thought conducive to long life in the lamps. As, however, it was found that, by augmenting or diminishing the weight suspended from the core-bars, the electromotive force could be brought back to its normal amount, it occurred to the author to fix an upright cylinder in direct communication with the boiler, and to make its piston-rod press upwards on the core-bars; the diameter of the cylinder being experimentally determined by obseving the weight necessary to be added or removed for certain variations in boiler pressure. This arrangement caused a very great improvement, and when the load was approximately the same it maintained the electromotive force constant under very considerable variation of steam pressure. When, however, the load was varied very considerably, say from one lamp to a hundred, it was found that more variation took place in the electromotive force than was desirable.

The arrangement was accordingly modified by causing the piston-rod to act upon a lever, and by introducing a second cylinder supplied with steam from the steam-chest, the second piston-rod acting upon the same lever but upon the other side of the fulcrum. The end of the lever was furnished with a steel knife-edge, bearing against another knife-edge set at right angles to it upon the prolongation of the core-bars. The cylinders were also both of them made larger, and were placed so that they could either of them be moved nearer to or further from the fulcrum of the lever, whereby the resultant effect of their differential power could be easily adjusted.

(To be continued.)

THE TELEGRAPH ACTS AMENDMENT BILL IN PARLIAMENT.

In the House of Commons on the 30th ultimo upon the motion to go into Committee on this Bill,

Mr. Alderman LAWRENCE having expressed his strong disapproval of any plan which would abolish free addresses,

Mr. SHAW-LEFEVRE hoped that the House would allow the Bill to get into Committee.

The House then went into Committee accordingly, and Clause 1 was agreed to.

On Clause 2,

Lord J. MANNERS rose to move the amendment of which he had given notice. He said he regretted that the necessity under which the right hon. member for Reading lay in moving the second reading of the Bill on the very afternoon on which the House adjourned for the Easter holidays, made it impossible for him to raise the question involved in his amendment on that occasion. But he had no alternative now except to ask the House to decide the issue between himself and the right hon. gentleman at the present stage. The point immediately at issue was the abolition or the continuance of free addresses. In what had fallen from the right hon. member for the city of London he entirely agreed. He objected strongly to the abolition of free addresses, and he should ask the Committee to come to a decision on that point. Both the right hon. member for Reading and himself, in dealing with that question, were under the same financial restrictions. The right hon. gentleman had told the House very frankly that he might have proposed a scheme of a more liberal character but for the necessity that was imposed upon him by the Treasury of not exceeding the estimated loss of £180,000 by his proposal. Now the Treasury had, wisely as he thought, imposed the same restriction upon himself; and he had therefore so to arrange his scheme of free addresses as not to exceed the estimated loss of £180,000. The experienced officers of the department had assured him that the scheme which he now proposed met that Treasury requirement. Therefore, in regard to the financial aspect of his scheme, and that of the right hon. gentleman opposite, they stood upon a perfect equality, and what the Committee had to determine upon was the respective merits of the two schemes. He wished the Committee to decide that question not with reference to the effect of either scheme upon one class of the community or on another, but with reference to the interests of the general telegraphing public. He held also that they ought to have regard not only to those individuals or those classes who now used the telegraphs, but they should endeavour so to arrange the change about to be made as to induce classes and individuals who had not hitherto been in a position to avail themselves of the telegraphs to do so in future. He said that the scheme proposed by the right hon. gentleman opposite would not fulfil those conditions. He admitted that with respect to certain important classes they might see their way to derive advantage under the right hon. gentleman's scheme. Merchants, stockbrokers, and similar classes who had fixed and —what was very important—registered addresses might gain under the scheme of the right hon. gentleman. Another class of whom he wished to speak with every respect and consideration—the betting fraternity—might also gain under the right hon. gentleman's scheme. But he said that the State did not give 11 millions for the purpose of taking over the telegraphs from private companies in order that the influential class of merchants, rich traders, and still less the betting fraternity, should be favoured at the expense of all the other classes of Her Majesty's subjects. But further he held that the scheme of the right hon. gentleman depended entirely on what he must regard as an arbitrary assumption, namely, that the people who telegraphed could conveniently and safely cut down the words in their addresses from the average of 11 to the average of five. He was not disposed to think, because extremely clever and ingenious officers of his department assumed that that great reduction could safely be effected in the number of words used for addresses, that it could be safely or conveniently effected by the great body of the telegraphing

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public. If when a person went to a telegraph office he always had one of those highly skilled and experienced officers of the department at his elbow to tell him how many words he might excise from addresses, that contention might be admitted. But that was not so. The great body of the telegraphing public would have to decide for themselves how many words it was expedient that they should use in addresses; and they must, in the last resort, be the best and only judges of what was and what was not a safe and satisfactory address, and whether it was one which would ensure that the delivery of the message would not only be certain but expeditious. The right hon. gentleman opposite, in one of his speeches recommending his scheme, mentioned the fact that in his office he had failed to discover any record of a decided opinion upon that point on the part of his lamented and distinguished predecessor. For himself, he was not surprised that the late Mr. Fawcett did not leave in the office any record of what he thought on that subject. But if he had left no such recorded opinion in the office, he had certainly expressed a decided opinion on the point in that House itself. Speaking on the 29th of March, 1883, Mr. Fawcett said: "There is no doubt much force in what the noble lord (Lord J. Manners) has stated, and that abolition of free addresses would bear most heavily on the poor. A well-known man's address is generally a short one, and in many cases would be simply the name of the town in which he lives; whereas a poor person's address would often have to name the court and the street in which he lived. It would be found that the poor person's address was often several words longer than the rich person's; and, therefore, to charge for the address at one halfpenny per word would undoubtedly press somewhat heavily upon the poor." So far as he knew —and he had several conversations with him after that debate—Mr. Fawcett never changed his opinion that the abolition of the free address, at any rate of the receiver's address, would be a great detriment to the poor class who might be anxious to use the telegraph. He would now quote the opinion of a gentleman engaged in business who had placed his view on that matter before the public. The noble lord then quoted various letters in support of his statement. He would state only one more class to which the abolition of free addresses would cause great inconvenience, and those were the officers, the non-commissioned officers, and soldiers of Her Majesty's service. There was no class which deserved greater assistance on the part of the House of Commons than the soldiers who served the Queen. Soldiers' messages were usually sent to relatives living probably in tenement houses or small streets or courts in the large towns of this country or in the metropolis, and the addresses were necessarily lengthy. In the same manner the messages sent to soldiers by their relatives required a large amount of description in order to identify them, and the claims of that class ought not to be overlooked. It had been found that the average length of soldiers' messages averaged sixteen words. It was very difficult to cut down addresses with any degree of safety, and if any hon. member doubted that let him try to do so in his own telegrams. The right hon. gentleman complained of the cost of this system of free addresses, which had been in operation for 16 years. But no complaint had been made by anyone outside the department, though no doubt the officers of the department thought that the addresses were unnecessarily long, and that they imposed unnecessary trouble and expense upon the department. But no complaint whatever as to addresses was made by the public outside. That being so, he thought the question was whether the department was created for the public or the public for the department. The right hon. gentleman had referred to the foreign system, basing his arguments on the allegation that a charge for addresses prevailed in nearly all foreign countries. He claimed that in giving free addresses we were ahead of and not behind foreign countries. Did any gentleman who had sent telegrams when abroad think that the method of charging for addresses was more convenient? His opinion was that it was a retrograde and a reactionary movement. How would it affect the people in many parts of Ireland, of Scotland, and of Wales, where the same surnames were largely repeated? Unless there was a full, clear, and distinct address you could not distinguish one Jones or Williams from another, and great uncertainty would arise in the delivery of telegrams. Reference had been made to a number of streets of the same name in this metropolis, and that was an important consideration. There were 54 Albert-villas, 61 Albert-terraces, 38 Avenue-roads, 60 Cambridge-terraces, 75 Charles-streets, 59 Church-streets, 52 Elizabeth-streets, 64 John-streets, and 70 Park-villas. If we abolish free addresses we should never get them back again. If the Committee would adopt the alternative scheme he suggested, there was nothing which would prevent its further application in the granting of more words for 6d. If the sanguine views of the hon. member for Glasgow were realised, and if the revenue were improved, nothing would be easier than to allow five or six words for 6d. with free addresses, the maintenance of which would add to the contentment and satisfaction of the great mass of the telegraphing community. If you once abolished free addresses, you might whistle for them afterwards. There was great elasticity in his scheme, because you could add words for every halfpenny, and at any rate it would work well until the anticipations of the hon. member for Glasgow were fully realised. The noble lord concluded by moving the following amendment:—"Clause 2, page 1, line 24, leave out sub-section (1), and insert—1, the charges for the transmission of written telegrams throughout the United Kingdom shall uniformly and without regard to distance be at a rate not exceeding 6d. for the first three words of each telegram, or for each telegram of less than three words, and not exceeding one halfpenny for each additional word; 2, the names and addresses of the senders and receivers of written telegrams shall not be counted as part of the words for which payment shall be required."

Mr. Shaw-Lefevre said that the course pursued by the noble lord with reference to the Bill had been entirely satisfactory to him. He had to thank the noble lord for the consideration shown to himself and to the Bill. Holding, as the noble lord did, so strong an opinion on the subject of free addresses and objecting so strongly to the abolition of them, it was not to be expected that he would adopt the Bill *in toto*. The noble lord, therefore, adopted a wise course in leaving to him the conduct of the Bill, and in proposing an alternative scheme as an amendment. The noble lord admitted that his financial proposition was sound and fair. In introducing the Bill, he stated that in the critical state of the finances of the telegraph service it was not possible in his opinion, and in that of the Treasury, to incur a greater loss than the estimated loss of £180,000. The noble lord had found the estimate accurate, and felt himself unable to propose a plan which would involve a greater loss. Therefore, the two plans were identical in this respect, and the House had to consider which was the more convenient. While objecting to the abolition of free addresses, the noble lord had abstained from saying much in favour of his own proposal, or quoting an authority in favour of it. Had any of those whom he had quoted had under their consideration the alternative scheme of the noble lord? Could he produce one authority in the department or outside it who would say that his alternative was satisfactory? He believed there was not one who would say that the proposal would be unsatisfactory and would give rise to dissatisfaction and to renewed agitation. His own proposal was to abolish free addresses, and to give twelve words for 6d., rising by 1d. for two words, but he was prepared to accept the suggestion of the hon. member for Glasgow, and substitute a halfpenny per word. Therefore, from 6d. upwards, the two schemes were the same. The only question was what was to be given for 6d., three words with address, or twelve without. Examination showed that of the twelve words five would be required for the address and seven would be left for the contents of the message, compared with the three of the noble lord. This estimate was the result of a long investigation, which showed that addresses could be reduced to five words or four, or even three. In many instances the sender's name could be omitted, and there was the provision that five figures were to count as a word. There was at present great telegraphic waste in addresses, and some of the examples were amusing. A milliner at Dover had used thirty-two words in describing her address. A noble lord who had gained some advantage in a Bill telegraphed the result of his success to a justice of the peace, and he used forty-six words in describing his own address and that of his friend. In the third case the late Postmaster-General telegraphed from the House of Commons to the head of the Telegraph Department informing him that this Bill would not come on; and he used eleven words for the two addresses. It was pointed out, however, that three words would have been sufficient, and if he had had to pay for the addresses he would probably have confined himself to that number. He had gone through a number of telegrams, and there was not one of them which did not contain superfluous words in the addresses. Therefore it was necessary to impose some limit in order to prevent the transmission of superfluous and unnecessary words, and he thought the only way of doing this was to give the senders of telegrams an interest in curtailing the addresses. If, in future, there were six unnecessary words in every telegram, and if they were multiplied by thirty millions—the number of telegrams which it was expected would be despatched annually when this Bill became law—they would amount to 23 per cent. of all the words sent over the wires. The very lowest estimate he had made of the cost was £250,000 a year. Now, was it not worth while to make some effort, even at a sacrifice of convenience to some classes of the community, to save so large a sum annually? The noble lord proposed in his alternative scheme to give free addresses and three words for 6d. Why did the noble lord limit himself to three words? It was on account of the great cost of the superfluous words sent in the addresses. If the noble lord could save these superfluous words and add them to the text of the message he would be able to give more words for 6d. Three words in the text were insufficient for almost any message. He had come to the conclusion that not one message in forty would be sent for 6d. under the noble lord's tariff. Inasmuch as there would be the same inducement under the noble lord's tariff as under his to cut down the words in the text as much as possible, he had come to the conclusion that under the noble lord's tariff the senders of telegrams would have to pay in every case for four additional words. The transmission of those additional words, if multiplied by thirty millions, would cost £260,000 a year. That £260,000 almost exactly met the cost of telegraphing superfluous words in the addresses. Forty per cent. of the telegrams would, he calculated, be sent for 6d. under his tariff, while, on the other hand, only one telegram in forty would be sent for 6d. under the tariffs proposed by the noble lord. This was not an assumption, but was founded on a careful investigation of a large number of telegrams. He had examined about 157 telegrams sent by working men, and had compressed them within reasonable limits, when it was found that 71 of those telegrams could be sent for 6d. under his tariff. It was also found that the average charge for all these telegrams would be 7½d. He had applied the same telegrams to the noble lord's tariff. The result was found to be that only four of them could be sent for 6d., and that the average charge on the whole of the 157 telegrams would be 1½d. more than under the tariff of this Bill. Which of the two tariffs would working men, therefore, be likely to prefer? The noble lord had mentioned various classes of people who objected to the tariff of the Bill, including Messrs. Sutton, of Reading, but he had reason to believe that if all their telegrams could be examined at the Post Office he should have a complete answer to all the statements which had been made. He had asked them for permission to to use their telegrams for the purpose, but they had not the fairness to allow the examination to be made. On all these points he thought the House would prefer the tariff proposed by the Bill to that of the noble lord. If only three words were conceded there was danger that the senders of messages would use part of the address as a code. He had shown that by the noble lord's tariff only three words were conceded; secondly, that every sender would be required to pay for four extra words as compared with the tariff in the Bill; thirdly, the average charge of each message

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would be from 1½d. to 2d. more than under the Bill; and, fourthly, no less than £250,000 would be expended in useless addresses. On the other hand, under his plan addresses would be paid for, and the department would be saved the expense of telegraphing 23 per cent. of useless words in the address.

Mr. GRAY preferred the plan of the late to that of the present Postmaster-General, but he saw no reason why they should not have the number of words given by the late Postmaster-General together with the free addresses of the noble lord. He was inclined to think that if the department were more carefully managed a message of 12 words and free addresses might be given for 6d. When the telegraphs were taken over by the State, Press messages were transmitted at the rate of 4d. or 4½d. a hundred words. If the telegraph companies found it remunerative to send Press messages at that rate there must be a great want of economy in the department if, as was stated, something like £150,000 or £200,000 a year was lost by the department in respect of Press messages. He felt sure that a more economical management in this respect would enable the Government to allow the present shilling message to be sent for sixpence.

THE CHANCELLOR of the EXCHEQUER said the Government could not agree to give a larger number of words and free addresses. The choice lay between the scheme of the late Postmaster-General and that of his noble friend, and the Government were prepared to carry out whichever of those alternative proposals the Committee preferred.

The Committee divided, when the numbers were—

For the amendment	62
Against	108
Majority	—46

Mr. SHAW-LEFEVRE said that in pursuance of the arrangement which had been entered into he begged to move that progress be reported.

Lord J. MANNERS having intimated that he did not propose to move any further amendments,

Mr. SHAW-LEFEVRE withdrew his motion for reporting progress.

The Bill then passed through Committee, and was ordered to be reported to the House without amendments amid some cheering.

On the 31st ultimo, Mr. Alderman LAWRENCE put a series of questions, of which he had given private notice, to the late Postmaster-General, who has charge of the Telegraph Acts Amendment Bill. He desired to know what course the right hon. gentleman intended to take with respect to the charge for numerals in the address of a telegram, and for the initials of metropolitan districts.

Mr. SHAW-LEFEVRE said that up to five figures would count as one word. He intended to move to recommit the Bill in order to substitute "a halfpenny a word instead of one penny for two words" in Clause 2. Practically the change would make no difference in point of finance. The initials of metropolitan districts would count as one word, not as two.

Mr. Alderman LAWRENCE asked whether an address such as "Oxford-street" would count as one word, and similarly the name of an island like the "Isle of Wight," "Isle of Man," and so on.

Mr. SHAW-LEFEVRE: I am afraid I shall have to say "no" to both the e questions.

Mr. Alderman LAWRENCE said that when the Bill was recommitted he would move that the amendments which he had alluded to should be inserted.

On the 2nd inst., on the third reading of the Bill,

Mr. SHAW-LEFEVRE moved to recommit the Bill, with the object of inserting an amendment in Clause 2.

Mr. Alderman LAWRENCE also moved that it be recommitted in respect of two other new clauses. His object was to secure that initials in the metropolitan district should not be counted as words, and that the names of streets, gardens, &c., be counted as one word.

Mr. SHAW-LEFEVRE said he could not accept the amendments.

The amendments were negatived, and the House resolved itself into Committee on the Bill on the original motion.

Mr. SHAW-LEFEVRE moved in Clause 2 the omission of the words "1d. for each additional two words or parts of words," in order to insert "½d. for each additional word."

The motion was agreed to.

The report of amendments was then brought up and agreed to, and the Bill was read a third time.

On the 3rd inst,

Lord J. MANNERS said it was hoped that the scheme for sixpenny telegrams would come into operation on October 1.

In the House of Lords, on the 4th inst., Lord MOUNT-TEMPLE, in moving the second reading of this Bill, said that it would confer a very considerable boon upon those persons who were now obliged to pay for 20 words when their messages contained less than ten words. It was calculated that if the Bill passed there would be a large increase in the number of messages sent, and there was no doubt that the measure would be a very great advantage to the public at large.

The Earl of MILLTOWN wished to know whether the Government assented to the Bill, and whether the first section meant that the name and address of the sender must be upon the message.

The Earl of IDDESLEIGH said that the Bill was introduced into the Commons by the late Postmaster-General. When it came on for discussion the present Postmaster-General proposed that it should be carried with an amendment of which he had given notice. His noble friend was defeated upon that, and thereupon left his predecessor to take charge of the Bill. So far as the Government were concerned they looked upon the Bill as one for which the late Government were responsible.

Lord MOUNT-TEMPLE said he was requested by the late Postmaster-General to take charge of the Bill. He understood that the sum of 6d. was to be paid for any number of words not exceeding twelve, and the sender might put them either in the address or in the message.

The Earl of MILLTOWN said that in Committee he would move an amendment in order to make the Bill more clear on the point raised by his question.

The Bill was then read a second time.

On the 5th instant the Bill passed through Committee and was reported without amendment to the House.

THE PIONEER CABLE.

A complimentary dinner was given on Wednesday night at the Star and Garter Hotel, Richmond, by Mr. Cyrus W. Field, to commemorate the twenty-seventh anniversary of the completion of the first Atlantic cable. A special train, conveying upwards of 200 guests, left Waterloo Station shortly after five o'clock, returning at the conclusion of the dinner. The chair was taken by Mr. Cyrus Field. Among those present were Sir Lyon Playfair, M.P.; Mr. Shaw-Lefevre, M.P.; Lord Houghton, Mr. Phelps, the United States Minister; Sir A. Otway, M.P.; the Lord Mayor, M.P.; Sir G. Campbell, M.P.; Professor Thorold Rogers, M.P.; Sir William Thomson, Sir S. Waterlow, M.P.; Sir W. Lawson, M.P.; Senator Hawley, of Connecticut; Canon Farrar, Sir J. Anderson, Sir D. Gooch, M.P.; Sir G. Elliott, M.P.; Sir Charles Bright, the Chief Justice of the United States, and others.

The CHAIRMAN, in proposing the toast of "The Queen," said American citizens always drunk this toast with as much enthusiasm as if they were British subjects. They could never forget that Her Majesty, in all her relations with the United States, had ever been actuated by the noble sentiments to which she gave expression in the message which she sent through the cable to President Buchanan in 1858. "The Queen," she said, "is convinced that the President will join with her in fervently hoping that the electric cable, which now connects Great Britain with the United States, will prove an additional link between the nations, whose friendship is founded on their common interest and reciprocal esteem." He had the honour to give "The Queen, God bless her."

After the toasts of "The President of the United States" and the "Illustrious Memory of General Grant" had been drunk,

The CHAIRMAN, in proposing the toast of the evening, "Success to the Atlantic Cables; May they Perpetuate the Peace, Friendship, and Prosperity of Two Great Kindred Nations," said that when the first telegraph land line in the United States was successfully completed many years ago the very first message which passed over the electric wire was sent by a lady of his acquaintance. She telegraphed these four pregnant words:—"What has God wrought?" And in briefly reviewing the history of the Atlantic cable he did not think he could use language more appropriate—"What has God wrought?" There were many eminent persons present who, having shared the labours and successes of that great undertaking, naturally regarded its history as "a twice-told tale;" but he felt sure that, even in this case, he should not be guilty "of vexing the dull ear of drowsy men." Personally he had much reason to feel grateful to Almighty God when he recalled the meeting at which the first important step was taken in the direction of establishing telegraphic communication between the two continents. That meeting was held in his own dining room in New York on March 10, 1854; and he was now the sole survivor of the little company which assembled on that occasion. More than three years elapsed before an attempt to lay a cable across the Atlantic was made; for it was not till the 5th of August, 1857—28 years ago—that the first expedition sailed from Valencia Island. Those who were present would never forget the lofty tone of eloquence in which the late Lord Carlisle, then Lord-Lieutenant of Ireland, spoke on the eve of the departure of the "Niagara" and the "Agamemnon" on their mission of peace. "Moral links," he said, "there have been—links of race, links of commerce, links of friendship, links of glory; but this, our new link, instead of superseding and supplanting the old ones, is to give them a life and intensity which they never had before;" and in the same sanguine spirit, he pointed out that while hitherto "the inhabitants of the two worlds have associated with each other in the chilling atmosphere of distance, they can now be hand to hand, grasp to grasp, pulse to pulse." These high expectations, however, were for a time destined to be blighted; for the cable was broken on board the "Niagara" after 335 miles had been sunk in the depths of the Atlantic. But, as their friends knew, they did not yield to despair; and their spirits revived when, on August 5, 1858, 27 years ago, the next cable was successfully laid. Unfortunately, it only had a brief existence of 27 days, for on the ensuing 1st of September it ceased to work. Great was their discouragement, and severe also were their struggles to raise money for what seemed to many people to be an insane venture. The attempt was not renewed till the year 1865, when the cable, after more than 1,200 miles had been paid out, was again lost. It was not till July 27, 1865, 19 years since, that the cable was successfully and permanently laid; and from that day to the present—thanks to the multiplication of cables and to the wonderful skill displayed in making and laying them—there had been no further interruption of telegraphic communication between England and America. When the first Atlantic cable was laid the largest submarine line in the world was that which connected England with the Continent of Europe. Contrast with this the fact that, at the present time, the oceans of this planet were spanned by no fewer than a hundred thousand miles of submarine cable. To the promoters of the Atlantic telegraph belonged the credit of having given the original impetus to this great work; and to them—as inventors, as electricians, as manufacturers, as financiers, as journalists, as statesmen—was due, in no small degree, the great expansion of submarine telegraphy which had taken place during the last quarter of a century. They had covered both earth and sea with a subtle and instantaneous means of

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intercommunication which was destined, in its far-reaching consequences, to bind together all the branches of the great English-speaking family, and to play an important part in advancing the general well-being and progress of mankind.

Senator HAWLEY, Sir G. ELLIOTT, M.P., and Sir J. ANDERSON having spoken,

The CHAIRMAN proposed the toast of "The men of science and enterprise to whom submarine telegraphy is so largely indebted," coupling with the toast the names of Sir. W. Thomson and Sir Charles Bright.

The health of "The Chairman," proposed by the LORD MAYOR, brought the proceedings to a close.

LEGAL.

Liardet and another v. The Hammond Electric Light and Power Supply Company (Limited).

This was an action brought by the plaintiffs, John Evelyn Liardet and Thomas Donnithorne, to recover the sum of £45,000, damages for the alleged breach by the defendant company of certain covenants in an agreement bearing date the 17th of June, 1882, and to enforce specific performance of the other covenants. The agreement was for the sale by the plaintiffs to the defendants of three patents—a patent for hydraulic motors, a patent for the arrangement of electric lighting apparatus in railway trains, and a patent for an apparatus for the storage of electricity. The price to be paid by the Hammond Company was £30,000, half in cash and half in shares, a deposit of £6,000 in cash being paid into the bank in the names of two nominees of each of the parties. The completion of the above contract was subject, however, to the following conditions, viz., that the vendors should prove before the 1st of the following December that the accumulators were practically half the cost for equal power and half the weight of the Faure accumulator, and that they were equal for commercial and practical purposes to the Sellon-Volckmar; failing which the deposit was to be immediately repaid the defendant company. The defendants contended that the plaintiffs had failed to give the required proofs, and claimed a return of the deposit money.

Mr. Barber, Q.C., and Mr. Macrory were counsel for the plaintiffs; the Attorney-General, Mr. J. F. Moulton, Q.C., and Mr. Ashton for the defendants.

Mr. Donnithorne, one of the plaintiffs, examined by Mr. Macrory, stated that he was one of the patentees of the Liardet battery. The battery manufactured for the Hammond Company was in accordance with the specification. Witness explained the process of manufacture. It was not at all like the Faure battery, because in that ordinary sheet lead was used, and in their battery foreign substances were introduced in the lead. In the Liardet battery the electricity was obtained at once, while in the Faure it was not produced until after several months' action had taken place upon the lead. His battery was half the weight of the Faure.

Cross-examined: He was a solicitor still in practice. Swore that the batteries submitted to the Hammond Company were constructed in accordance with the specification and the manner described by him that morning, with the exception that porous cells were used instead of the two porous plates. Could not say whether his description accorded with that in Dr. Hopkinson's report. Had seen the Sellon-Volckmar battery in use at the Crystal Palace Exhibition in 1882. The Alhambra Court was lighted there by means of them. Had not tested them, as he had no means of doing so.

This concluded the plaintiffs' case.

Mr. MOULTON submitted that there was no case made out by the plaintiffs, and was about to give reasons, when

His LORDSHIP intimated that he need not trouble. He had heard the evidence of a solicitor, one of the patentees, who had suggested that the things, viz., the Sellon-Volckmar accumulators, with which the proofs as stipulated were to be given before the 1st of December, could not be obtained. Well, if so, so much the worse for the people who had to furnish them. Further than that, the description given by the only witness called before him of the battery made for the defendants seemed totally different to that in the specification. He therefore dismissed the action with costs, and ordered the return of the deposit to the defendants.

COMPANIES' MEETINGS & REPORTS.

The Anglo-American Telegraph Company (Limited).

The ordinary general half-yearly meeting of the proprietors of the Anglo-American Telegraph Company (Limited) was held at the City Terminus Hotel, Cannon-street, on Friday last, the Right Hon. Viscount Monck presiding.

The SECRETARY (Mr. T. H. Wells) read the notice convening the meeting, and the minutes of the last half-yearly meeting, which were approved by the present meeting and signed as correct by the Chairman. The report of the Directors was taken as read.

The CHAIRMAN: It now becomes my duty to move the adoption of the report, and in doing so I shall not adopt the plan I have usually pursued of comparing the figures of this half year with those of either the preceding or corresponding half year, and for this simple reason that the conditions under which we have been working this half year are so completely different from those which prevailed in former half years that the comparison would be useless. Gentlemen, we have been operating during the past half year under the influence of depressed trade, increased competition, and diminished tariff. We have also in addition to these disadvantages been specially unlucky in regard to our cables. I mentioned to you at the last half-quarterly meeting that several of the cables belonging to our combination were out of order and not working. I regret to say that that state of things has not been completely got rid of yet. We have still cables of the combination incapable of carrying messages across the Atlantic, one of the Jay-Gould and one of the Pouyer-Quertier Companies'. Every effort is being made to repair these cables, and I trust that before long our whole system will be in operation. It will be evident to you that this state of things places us at a very great disadvantage in more ways than one. In the first instance it increases our expenses by compelling us to do more than our proper share of the whole traffic without any proportional increase in our incomes. In the next place it ties our hands very much with reference to the competition of those who are opposed to us, because it would be madness for any man or any set of men to embark in a hostile competition, or war of rates, even if such a policy were deemed advisable when the weapons of warfare were not in proper order. In addition to this consideration, which affects us in another way, our opponents have not had much experience of the working of ocean telegraphy, and of course they are very much guided in their views in respect to the future and their relations with us by the receipts they obtain. Now, you are all aware, because I have often noticed it from this place, that we have observed in our experience that there is a rule which regulates the distribution of traffic among competing cables, and which acts almost with the certainty of a natural law, giving to each cable competing its allocated part of the entire traffic. From this it naturally and necessarily follows that the smaller the number of cables there are in operation at any one period, the larger the receipts of each will be, and therefore the commercial cable as it is called—the Mackay-Bennett cable—is at this moment receiving a larger share of the traffic than it would do if all our cables were in operation. Well, all I can say is this, that we are doing our best (when I say we, I mean our allies as well as we) to place our plant in proper condition, and I trust that before long we shall be in a position either by a hostile competition, if that should be considered desirable, or by the force of circumstances, to bring our opponents to a sense of reason and to induce them to take steps which may enable us all to gain a living. I am not despondent on the subject. I believe such an arrangement can be come to and is quite feasible. It is difficult to speculate what will be the conduct of men who, as far as our judgment goes, have already shown so much recklessness in spending large sums of money on telegraph cables when there was really no need of them. But I don't believe that they are so different from the rest of mankind as to forego a profit on their capital in the interest of pure philanthropy and cheap telegraphy. That being so I trust that before long we shall come to some arrangement which will enable us to give you a more satisfactory dividend than, I am sorry to say, we are capable of giving on the present occasion. I now come to our old friend, or enemy, whichever you may call it, the renewal fund, and in opening my observations on that portion of the case perhaps you will allow me in all good feeling and good humour to say a few words in deprecation of the heated and angry tone which characterised the discussion on this subject on the last occasion of our meeting in this room. Now this is a mere matter of business, and we can surely afford to discuss it without getting excited, or using language which I am certain those who used it were sorry for afterwards. This question has been discussed as if your Board had some unworthy personal motive in the policy which they had adopted. Now, I think if you reflect for one moment you will see that nothing but a strong sense of duty would have induced the Board to take up the position they did take up. You may differ from them in opinion, but I am sure you will all allow that if they could have conscientiously done so it would have been much more agreeable to the Directors, to use a slang phrase, to make things pleasant all round, and meet their constituents with smiling faces. We could not, however, do so as men of business, as men of conscience, and as efficient managers of your affairs. In the discussion that has taken place it seems to me as if the contributions which we make to the renewal fund were regarded as having been adopted by some rule of thumb—a mere chance shot at whatever would do to replace the cables. I assure you that is not the case. This sum was arrived at—and I may mention in a parenthesis that this sum was approved of by the shareholders—["No, no," and hear, hear]. I beg the gentlemen's pardon. I have always been Chairman of the Company, and I remember perfectly well what occurred at former meetings—it was approved of at former meetings of the shareholders over and over again. It was arrived at not by any mere rule of thumb or guess work, but by elaborate calculations based on the best information which we could obtain and on the opinion of those most competent to advise us. I beg leave to say for myself—and I believe I speak the feeling of my brother Directors—that no change has taken place in my opinion either as to the legal liability of the Directors, which I have often stated from this place, or as to the general principles on which our renewal fund should be based. There are two elements which we must of course consider in endeavouring to ascertain the annual amount to be set aside towards the renewal fund. One is the duration of a cable in a state of efficiency, and the other is the cost of replacing it. On these two elements of course depend—it is a mere actuarial calculation—the amount that is necessary to set aside for the renewal fund. Now, with regard to the first of these elements, the duration and efficiency of a cable, of course every year that a cable lasts gives you stronger faith in its continuance. But it is an element that is not capable of being very accurately measured in figures. The other element, the cost of replacing it, is one very capable of being measured in figures. I am happy to tell you that on a careful reconsideration of the whole case your Board have discovered a mode in which a large economy can be effected in replacing your cables, and this has enabled them so far to meet your wishes without

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sacrificing their own convictions in this half year, and in future half years, to reduce the large contribution towards the renewal fund to £50,000 per half year. That is taking off £50,000 a year from the contribution which has hitherto been made to the renewal fund. We propose that that state of things—assuming that there is no disturbing cause at work—should continue for three years, and we then hope we shall be able to make a further reduction from the contribution to the renewal fund. I hope I may count on the confidence of the shareholders in reference to this matter. The difference between the management of a private firm and a joint-stock company is this, that a private firm need not give to the public any information as to the management which it may think unadvisable for the interests of the firm to mention. A joint-stock company, on the other hand, if it has not the confidence of its shareholders, and the Directors are obliged to declare to them all the motives of their actions, cannot do so without taking the public into its confidence also, and thereby very possibly compromising the interests of the Company. I make this observation because I do not think it would be advisable to state here what it is or in what respect we mean to make that economy which I told you enables us to reduce the contribution to the renewal fund. As I said before, I trust that any discussion that takes place on this subject will be conducted with order and regularity, and, let me add, in conformity with the Articles of Association of the Company. The Articles of Association have been sneered at, and we are told that they are hurled at the shareholders' heads. But we cannot manage this Company, or any business, without having rules for our management. These rules are embodied in the Articles of Association, but there is a prescribed clause by which these Articles of Association can be altered if they are opposed generally. But as your Chairman, who must see that order is maintained while these rules form part of the Articles of Association, I should be acting illegally and should subject myself to legal penalties if I did not see that that was the case. I trust this being the law of the land you will not, if things are pointed out as not being in conformity with the Articles of Association, sneer about the Articles being hurled at your heads. I should be guilty of a dereliction of duty if I did not see that those Articles of Association were enforced. I will not detain you longer, but will now move, "That the report of the Directors and the accompanying statement of accounts to the 30th June, 1885, submitted to this meeting be and the same are hereby received and adopted."

The Most Hon. the Marquis of TWEEDDALE seconded the motion.

Mr. THOS. SMITH questioned whether the Directors were men of business, as the Chairman had said, in view of the beggarly dividend which they were paying to the ordinary shareholders, while they were not paying much more to the preferred shareholders. He could not call them men of business when they divided £35,000 among the shareholders, and put £62,000 odd on one side which they could not touch. He intended to submit the following motion:—"That no further additions to the so-called renewal fund should be made from the 1st of the present month, with the exception of the accruing interest." He considered that a very simple resolution which every shareholder could understand. To some extent since the last meeting the Directors had admitted the fairness of this proposition; but when he remembered that at the end of this half year the so-called renewal fund would represent an amount of over £800,000, with merely the addition of the interest to it, he thought, considering the distress and suffering of the smaller shareholders, that it stood at a sufficient amount for the requirements. He had had a great many letters from shareholders in all parts of the country, complaining of the action of the Board in setting aside to the renewal fund twice as much as they were going to distribute among the shareholders. He had bought his preference stock at £90, and it was now £47 or £48, representing a very serious loss to his representatives if anything happened to him and his executors had to sell his holding in the market. Since 1880 the Directors had taken from the shareholders £1,400,000, of which £800,000 now remained at the credit of the renewal fund, £600,000 having been devoted to laying a new cable, which was given into the hands of the Telegraph Construction Company without any competition from others. He supposed that some day that the £800,000 now in the renewal fund would be used, without heeding the shareholders, for laying two new cables. Well, they were never asked before for their sanction, and he did not suppose they would be asked in future. But he maintained that they ought to be consulted in the matter. He thought they would agree with him that an end ought now to be put to the flagrant injustice and robbery of the shareholders by continual additions to the renewal fund, for which he contended there was no necessity. If they required two new cables at once, and they were to put up the work to public competition, they would get them for less than £800,000. He was told so by authoritative persons. They did not want to lay new cables from shore to shore, but only the deep sea portion, as the shore ends were always good. If, however, a few more thousands beyond the £800,000 were required, it could be very easily raised with the splendid credit enjoyed by the Company. The Chairman was also the Chairman of the Brazilian Submarine Company, and when they laid a new cable he did not take all the money out of the renewal fund, but forestalled the future by issuing redeemable bonds, and in this Company they ought to be treated in the same way. In the seventh paragraph of the report, the Directors had said that the £150,000, annual contribution to the renewal fund, had been adopted with the full consent of the shareholders, but this he denied. When he first brought this question of the renewal fund before the shareholders he was laughed at, but now that they were being pinched, they seemed to think that he had not been far wrong.

Mr. SEELEY seconded the motion, and having spoken of the small dividend which was going to be paid, argued that their affairs had for a long time been going from bad to worse, and that the Company was really a nursery ground for other companies. They repaired the cables of other companies, found ships for them, and transmitted their messages,

The MANAGING DIRECTOR (Mr. Weaver): At a price.

Mr. SEELEY: Do we make any profit out of it?

Mr. WEAVER: Certainly.

Mr. SEELEY said he would prefer the Company to dissolve all their existing arrangements with other companies and stand on their own bottom. They had four good cables, and a reserve fund of an amount equal to two more, and if they were working alone he was convinced that they would earn more than a dividend of one per cent. This state of things could be altered by adopting the suggestion which had been made of not adding further to the renewal fund.

The CHAIRMAN: It is right that I should tell you that this resolution proposes substantially to alter the Articles of Association. The Articles provide that before declaring a dividend the Directors shall set apart to the renewal fund whatever they in their discretion should consider desirable, and this resolution expressly forbids them doing anything of the sort. It takes away the discretion. It may be right or wrong that the Board should have that discretion; but as long as that provision remains in the Articles of Association I cannot allow such a resolution as this to be put to the shareholders.

Mr. SMITH: Then why call a meeting of the shareholders at all?

The CHAIRMAN: I do not wish in any degree to appear to desire to muzzle the shareholders. I must follow the Articles of Association. If the shareholder desires to pass this as a recommendation to the Directors there is no objection to it, and I will put it to the meeting. It is legal to put it as a recommendation to the Directors.

Mr. SMITH assented to this alteration.

Mr. STOCKDALE supported the motion of Mr. Smith, as he was one of the shareholders in the Company who were not in accord with the Board as to the question of the sum that it was desirable to put to renewal fund. He, in conjunction with a few other large and influential shareholders, determined to ascertain the views of the general body of the shareholders on the subject. They therefore went to the trouble and expense of sending out a circular and a blank form of proxy, desiring those who agreed with them that it was time that no further appropriation should be made to the renewal fund to send in their proxies in favour of himself and friends. They received a very considerable number of proxies which on Wednesday last they, in accordance with, as they thought, the regulations on the subject, took to the officers of the Company at 11 o'clock in the morning, which was more than forty-eight hours before the time appointed for the present meeting. But they were told by the Secretary that he could not receive the proxies because they had not been delivered at midnight on the previous evening. He wished to know if the Board meant to take advantage of such a mean subterfuge and not to accept the proxies. If so, he maintained that only one deduction could be drawn from such conduct, which was that they were afraid to go to a poll on the matter. The Chairman at a meeting a year ago had stated that the Brest, as being the oldest cable, would probably be the first to break down, and that the sum required for its renewal would be £800,000 or £900,000, and that therefore the £150,000 a-year set aside to the renewal fund would go on. He did not hesitate to say that the Chairman's estimate for the repairs of the Brest cable was some hundreds of thousands out, and that three cables could be put down instead of one for the figure mentioned, for the probability was that the shore ends of the cables were better than ever, and in that case they would only have the deep sea portions to lay. If the Directors did not willingly act on the advice of the shareholders and cease adding anything more to the already large and inflated reserve fund they would not relax in their efforts to make them. There were five Directors on the Board who between them held only £8,350 of the stock, which was worth at the present time about £2,400, and those five Directors formed a majority of the Board, and according to their interpretation of the Articles of Association those five men had full power at their own will to do what they liked with the £800,000 at the credit of the renewal fund. There was no wonder that their shares stood so low in the market, and that people had no confidence in buying them. He thought a clause ought to be added to the Articles of Association to the effect that the qualification of a Director should be at least £10,000 stock, which would give them some interest in the concern.

Mr. JACKSON, referring to the seventh paragraph of the Directors' report, stated that the Board had not been severely criticised and strenuously opposed for forming a renewal fund, but on account of the exaggerated and excessive amounts taken from the impoverished shareholders when that fund had reached an amount that the Board, he ventured to say, never expected to see. They had, in fact, he maintained, two new cables now in their renewal fund, and it was to be remembered that of their four cables three of them had virtually, and two of them absolutely, been replaced out of their dividends. Contributions to the renewal fund ought, therefore, to cease.

Mr. GRIFFITH said that the shareholders had been told that the renewal fund had been accumulated on the principle of a sinking fund. He maintained that that was a most erroneous principle for them to go upon. The Chairman had spoken of the sense of duty, but he (the speaker) thought that the sense of duty that had guided the Directors had rather carried away their judgment. On a previous occasion he found from the reports that they had a cable 1,100 miles long, purchased and laid down for £475,000. But surely in the last few years the price of cables had diminished owing to science and competition, and they ought, therefore, to obtain cables at a lower rate. Therefore, what resulted from the figures before them was this—that in a short time they would have enough to lay down two new cables, which, however, he contended, were certainly not wanted, especially in view of the working arrangements which they had with the other Atlantic companies. He had a high opinion of the Chairman and of his sense of duty, but he did not think that all the Directors were unanimous with him, for at a meeting eighteen months ago Lord Tweeddale, who presided, admitted that these large additions to the renewal fund ought to cease. There was no necessity for accumulating

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the renewal fund to such a large amount, and the loss of dividend which that proceeding entailed was severely felt by the shareholders, who, moreover, saw a great depreciation in the market price of their stock. He hoped the Directors would not be hurried by their sense of duty into a policy of war to the knife with their opponents.

Mr. BURTON said he regarded the amendment as a vote of censure on the Board, for it implied either that the Board were not men of business or not so capable of judging what was for the best interests of the Company, or else that they were guided by self-interest. For his part he believed that the Board, from their long experience, their well known character, and the opportunities they had of viewing the question from all points, were better able to judge what was best for the interests of the Company than Mr. Smith and his friends. One argument in favour of those who preceded him was that by not giving more dividend the stocks of the Company were depressed in the market. But that was a matter of opinion. If they paid £50,000 away in dividend, so far as he was concerned he would not be prepared to give so much per share if he went into the market to buy, as he would if they put by that £50,000 to meet future emergencies. He regarded the renewal fund in the light of an insurance, and for the best interests of those shareholders who were permanent. It had been said that they had laid two cables out of dividends. But supposing those cables had not been laid, what price would their shares have been at in the market?

Mr. PRUST said that his views had very much changed since the last meeting, and seeing now that the preferred shareholders were cavilling on account of their dividends, he was in favour of the £800,000 being increased till it got to a million, when he hoped the Directors would be satisfied and keep it intact. At the last meeting he joined in the attack that was made on Mr. Cyrus Field, but he had since inquired into the charges that were then made, and, as an English gentleman, it was his duty to say that those charges were perfectly unfounded. They were to the effect that Mr. Field was concerned in competitive schemes against the interests of this Company; but from what he had learned since the last meeting the very opposite had been the case, and Mr. Field had always laboured for the shareholders, and not against them.

Mr. SMITH, in reply to one remark of Mr. Prust, stated that he held £45,000 worth of the deferred stock, and, therefore, in what he had said he had not been guided by personal motives, which Mr. Prust seemed to think.

Mr. JOHN NEWTON also desired to apologise for the part which he took at the last meeting in connection with the charges made against Mr. Field. Referring to the latter clause of the seventh paragraph of the report he stated that he had made no suggestion that the interest of the renewal fund should be divided. What he had suggested was that it should be shown clearly in the accounts what they placed to the renewal fund—£175,000 or £125,000, whatever the case might be—in the year. He thought that the deferred and the preferred shareholders should be brought together, and suggested that if one of the cables broke it should not be renewed. They ought to find some way by which the existing generation of shareholders should get a return for their money.

Mr. TROTTER expressed approval of the steps taken by the Directors in reducing the contribution to the renewal fund, but he wished they could have gone further and decided to increase that fund by only £50,000 a year instead of £100,000. The Chairman had made some remarks about the Articles of Association, but he could not help saying that, not being present at the last meeting, and having read the account of the proceedings, it had seemed to him from what took place that the shareholders in general meeting could do nothing. He therefore obtained a copy of the Articles of Association and read them, and then asked himself for what object were these meetings held, for there was literally nothing which the shareholders could do, framed as the Articles of Association were at present. The Directors could pass a resolution if they pleased that no dividend should be paid to the shareholders for the next ten years, and that the whole of the earnings should be applied to the renewal fund. He thought it would be wise for the Board to make such an alteration as would give the shareholders the power of at least determining questions which were of importance to their interests. The Board thought that the affairs of the Company had been wisely managed. He wished that he could agree with that view, but he could not, nor apparently could the public. The stock of the Company was £7,000,000, the market value of which was about £2,000,000 [A Voice: "£1,600,000]." He thought it was more than that. If they took from that sum of £2,000,000 the £800,000 to the credit of the renewal fund, it would be seen that the four cables of the Company, in the estimate of the public, were worth only about £1,250,000, and they knew that the four cables could not be laid for less than double that. In 1866 he bought 10 shares in the Company at £14. 10s., and in 1867 he bought more of the £10 shares for £18, and since then he had always continued to be a shareholder. He wished, with his £100 stock at £30, that he could believe the management of the Company had been entirely wise, and such as to command the confidence of the public. He did not believe in dividing the whole of the earnings among the present shareholders, or in putting an exaggerated amount by for future shareholders. There was some medium, and he trusted the Directors would see the wisdom of finding it.

Mr. VEARES objected to the continual increase of the renewal fund.

Mr. CHESTER thought that, in view of the statement which had been made that five of the Directors held together only £8,000 stock, and constituted a majority of the Board, they ought, as men of business, to pass the following resolution, or, as the Chairman pleased, recommendation to the Board:—"That no contract for the laying of any new cable be entered into by the Board of Directors without first obtaining the consent of the shareholders in public meeting." Having referred to the condition of the cables belonging to this Company and to the arrangements which had been entered into with other companies, there was, he contended, no reason why his proposal should not be accepted.

Mr. CYRUS FIELD, referring to the attack which was made on him at the last meeting, said he would read the concluding portion of a letter which Mr. William Abbott wrote, addressed to Mr. Burt, the solicitor of the Company, a letter which reflected credit on Mr. Abbott. The part he would read was as follows:—"Under these circumstances it affords me pleasure to withdraw the statements which I made at the last meeting of the Anglo-American Telegraph Company, and to express my sincere regret that Mr. Field should have experienced pain or annoyance from what occurred through the action which I took, as I considered, in the interest of the stockholders of that Company." Then there has been a frank retraction from every shareholder who made any remarks against me. I do value very greatly the opinion of my English friends (among whom are many of the best friends I have in the world), and desire to keep what I have gained in over thirty years—their confidence and their respect. I do not feel as despondent as some of you appear to be about the Anglo-American. The Anglo-American has four cables, and pools its receipts with four belonging to other companies. Three of its cables are landed in Newfoundland, and one at St. Pierre, near the coast of that island, and on the 6th of February (the day of your last meeting of shareholders) they were the only ones that were working. The other four were all broken. Two have since been repaired, but two still remain useless. The Mackay-Bennett cables were both broken soon after they were laid. They were repaired, but one was again broken this week. Thus of the ten Atlantic cables, everyone has been broken within the past year except those of the Anglo-American Company landed in Newfoundland. Could anything show more conclusively that a cable laid direct from Ireland to Newfoundland, across the great telegraphic plateau, is much more likely to be kept in working order than a longer line traversing other parts of the ocean? Where would your Company be now if it had no connection with Newfoundland, and had been obliged to seek a landing on some more distant point of the American coast? Yet you could not have touched Newfoundland without the consent of the Newfoundland Company, which had an exclusive right for fifty years to land cables on that island. Sir James Anderson, who has had great experience in the landing of cables in different parts of the world, can tell you what he considers these exclusive rights are worth to the Anglo-American Company. I beg to return my sincere and grateful thanks to Lord Monck, Mr. Weaver, and the 1,068 shareholders who supported me, against a minority of 3, on February 6th, for the confidence they expressed in me—the first two by their speeches, and the rest by their votes. Their esteem I value so highly that I should deeply regret if any of them had attached the slightest credence to the voice of misrepresentation and calumny which was so unexpectedly raised against me in my absence. Probably a good deal of the excitement which prevailed at the last meeting was due to the smallness of the profits divisible among the shareholders. I would remind those who are dissatisfied with the position of the Company that the Directors have not made that position, but are the victims of circumstances beyond their control. They should remember that the successful laying of our two cables in 1866 unfortunately produced an exaggerated idea as to the profits which the undertaking might be made to yield. This has led to a too keen competition, which in its turn has naturally borne fruit in fluctuating tariffs and diminished dividends; but the fault of this untoward state of things assuredly does not lie at the door of the Directors, who, I firmly believe, have done all in their power to administer the affairs of the Company with efficiency and success.

Mr. WILLIAM ABBOTT said that the reason why he had withdrawn what he had said at the last meeting about Mr. Field was that Mr. Burt, the solicitor of the Company, had given him proof beyond all doubt that Mr. Field had nothing to do with the Wabash Railway or with the competition of the American Union Company, by which the pooled receipts of the Anglo-American Company had been reduced by about 22 per cent. He, however, wished Mr. Field to understand that the shareholding public in England were six months ago, as they were now, in a condition of great excitement as to the state of American investments, and it had been generally stated (he knew now wrongly stated) that Mr. Field had had something to do with the two concerns which he (Mr. Abbott) had just mentioned. He urged on Mr. Field to try and impress on the railway magnates of America the duty of acting honestly towards those who had entrusted them with their capital. As one gentleman who had spoken had so well pointed out the public had no idea of the inherent strength of this Company, and of the fact that something like £600,000 or £800,000 had already been spent out of revenue, not in "watering" the Company, but in strengthening. He thought that all who were coming into the concern as shareholders should know what amount had been subscribed by or paid out of the pockets of the present shareholders in strengthening the Company. He had been amazed at the freshness of Mr. Smith in thinking that he could do anything with the Board, so fully intrenched as they were behind the Articles of Association which they had so ostentatiously on the table at that meeting. Mr. Smith, however, might rest assured that the feeling among the shareholders to manage their own affairs was steadily growing.

The CHAIRMAN: I will now try and answer the different criticisms which have been made. In the first instance let me say that there are two general propositions stated to which I consent with the greatest pleasure. One is that the Board feel no ill disposition towards the shareholders because they have criticised our proceedings. It has been asked, what is the use of these general meetings? The use of such a meeting, as it appeared to him, was to give the Directors an opportunity of ascertaining the general views of the shareholders, and enabling them so to qualify their views as to meet as far as possible the wishes of the shareholders. That has always been my desire and my practice during the many years I have been Chairman of this Company. The other proposition is one that Mr. Abbott has just made, which is, that it is becoming more the fashion of shareholders to look sharply after their own interests. I am delighted to hear it. Nothing in the world gives me greater pleasure than to see the

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shareholders come forward and express their views on the policy of the Board, and of the government adopted by the Board. On the other hand, I must protest against the idea that Directors are not to direct. If you do not concede that your Directors are managing your affairs on proper principles, or if you have not confidence in their integrity or honesty, turn them out. But I do not think it is right when Directors come before you, as we do, with a full candid declaration of policy and the reasons of the policy which they adopt, to say that the Articles of Association protect the Directors in the course they are taking, and that you are muzzled and can do nothing. That is not the fact. You have the power of turning out the Board and of altering the Articles of Association if you consider them against your interests. We are now discussing this burning question of the renewal fund. It has been over and over again before you. It has been thrashed out till there is not a grain of wheat left in it. At the last meeting we discussed this question for three hours, and I have not heard to-day a single observation which was not made and answered at that meeting. There was a full report of that meeting printed and distributed among the shareholders. In our half-yearly report we hark back on the subject. We call the attention of the shareholders to it, tell them on what grounds we were acting, and the lines we intend to pursue in the future, and we asked them for their proxies in support of that policy, and here they are (pointing to proxies). We have had a larger number of proxies sent to us on this occasion than we have ever had before. Under these circumstances, the question having been fully discussed, I hope, gentlemen, you will not consider it disrespectful if I do not take up the time of the meeting in answering in detail the observations which have been made. I think you have the whole case fully before you, and we are quite prepared to stand or fall by your judgment. May I ask Mr. Smith to let me put the resolution for the adoption of the report first?

Mr. SMITH: You pledge yourselves that the Directors will take this recommendation into consideration.

The CHAIRMAN: A recommendation from the shareholders will always meet with the respectful attention of the Board. He then put the motion for the adoption of the report and accounts, and declared it carried with one dissentient. Continuing, he read Mr. Smith's motion, and said: With regard to that, as I have said before, any recommendation coming from the shareholders, will be considered by the Board of the Company. But at the same time it must be evident to any one who has read our report that unless we entirely change our minds we cannot give effect to this recommendation. Therefore I should not like Mr. Smith to go away with the notion that we accept this recommendation as what we are going to adopt. I shall vote against it.

Mr. PRUST: Will you give us distinctly to understand that you will consider one million enough for the renewal fund?

The CHAIRMAN: What we intend is fully stated in the report. Mr. Burt calls my attention to the fact that what is stated in the report is not that we should stop when we get a million, but that at present we have £788,331, and that we mean for three years—this year and the two following years—to add £100,000 to that amount. After that period we hope that a still further reduction will be made in the amount added to the renewal fund. That is the statement in the report. He then put Mr. Smith's motion, and said it was carried, 29 having voted in favour of it and 26 against it. A poll was then demanded on behalf of the Directors.

Mr. SMITH said it was useless to have told him to put his motion in the form of a recommendation, and then for the Directors to vote against it. They did not intend to adopt it, and the whole thing was a farce.

The CHAIRMAN: It is impossible that we could allow 30 shareholders to control 20,000. I have received a requisition signed by five shareholders for a poll, and it will be taken immediately after the conclusion of the business, and closed at three o'clock. It is now proposed by Mr. Chester, as a recommendation to the Directors, "That no contract for the laying of any new cable can be entered into by the Board of Directors without first obtaining the consent of the shareholders in public meeting." Having put the motion in the usual way he declared it carried, 29 having voted for it and 18 against it. He intimated that a poll could be taken on this motion as well as on that of Mr. Smith.

Mr. SMITH said that the Directors could take the poll by themselves, as the shareholders would not oppose them, it being a mere farce to do so with the proxies of the Globe Company.

On the motion of Mr. EDWARDS, seconded by Mr. NEWTON, a vote of thanks was passed to the Chairman and Directors, and the CHAIRMAN having briefly returned thanks the proceedings terminated.

The adjourned meeting was held on the following day (Saturday), Sir James Anderson in the chair. He stated the results of the polls to be as follows:—

Votes representing £6,753 stock had been given for the recommendations, whilst votes representing stock to the value of £2,598,511 had been given against them. The recommendations were therefore rejected by a majority in favour of the Board of 32,920 votes, representing stock to the value of £2,591,758.

Submarine Telegraph Company.

The half-yearly meeting of the proprietors of this Company was held at the Company's offices, 2, Throgmorton-avenue, London-wall, on Tuesday last, under the presidency of Sir Julian Goldsmid, Bart.

The SECRETARY (Mr. S. M. Clare) read the notice convening the meeting and the minutes of the previous meeting, after which the Company's seal was affixed to the register of shareholders. The report and accounts were taken as read.

The CHAIRMAN then said: You will observe by the report that the gross receipts amounted to over £66,000, which enables us to add the usual 15 per cent. to the reserve fund, and to pay a dividend at the rate of 15 per cent. per annum, which leaves a balance of £889. That shows a considerable increase over the corresponding period of last year. Of course you can easily understand that the troubles in the East and the change of Government, and various other circumstances, have led to a considerable increase of telegraphing between this country and the Continent, and the result is shown in the figures which we put before you to-day. I cannot myself think—I never like to mislead you—that this is a permanent improvement of traffic, or sufficient to give us a permanent increase of income, because, as far as my experience goes, you have these fits and starts in telegraphy just as much as you find them in every other kind of business, and I do not see that general improvement in business which would lead me to believe that we should have an improvement in our affairs. I think the one thing goes with the other, and although we are told that the promising time has come, it has not yet come it seems to me; but when it does we shall hope to realise some advantage from it. I do not think the time has come for us for another reason also (because I look on the statement which I now hold in my hand with some alarm—a statement which always interests me, and, I think, has interested the shareholders considerably), and that is the number of words per message, and the average length of messages. In 1884, by the end of June, we sent 1,377,419 messages. Those messages contained 16,583,147 words, and their average length was 12·04. During the same period of 1885 the total number of messages transmitted was 1,462,430, showing an increase of 85,000 messages. The words in 1885 were 17,134,855 as against 16,583,147, showing a large increase—nearly 500,000—and the average length of each message was 11·72 words. You will therefore see that the average length of messages is continuing to decrease. I have been asking the Secretary to-day, and I find that during the month of July this year has shown a still further decrease, so that we have not got to the limit of the decrease yet, which of course considerably affects our profits. There is one circumstance which accounts for a considerable amount of the increased profit, and that is the condition of our cables. You will remember that I have stated to you on more than one occasion that for a long time it was my duty constantly to press the Government to make some arrangement with regard to the condition of the Dutch cables, and after a great deal of work and considerable delay—in fact, after many months had expired, we at last induced the Government to take the matter in hand, and they replaced one rotten cable altogether by an entirely new one, and during the past winter they have put in thirty miles in the other one; so that I may say they are now both in excellent order. I had the pleasure of talking with the Dutch Minister here this morning, and he said that there have been no complaints since this work has been done, so that shows that to the mercantile classes the change is very satisfactory. To us it is still more satisfactory, because the amount expended on cables during the half year under review was only £629, whereas before the sum spent on cable repairs was £2,684. Therefore we have spent £2,000 worth less of cable in the half year mainly owing to the condition of the Dutch cables. That accounts for the large diminution of outlay. There is one thing in which we have an increase of cost, and although it is money out of the pockets of the shareholders it is not a subject of unmixed regret. We established some years ago a scale of increase of wages, and from time to time, owing to their length of service, a considerable number of persons have risen to a higher scale. I do not think that is a matter for regret. I believe it enables you to obtain a good staff, and to get your work properly and efficiently done. That is practically the condition of our affairs. We bear in mind constantly to be economical as far as possible, but there are some things which are entirely beyond our control. He concluded by formally moving the adoption of the report and accounts.

The Hon. ASHLEY PONSONBY seconded the motion, which was carried unanimously.

The CHAIRMAN next proposed the declaration of a dividend at the rate of 15 per cent. per annum, less income tax, for the half year ending June 30th last.

The Right Hon. ROBERT BOURKE, M.P., seconded the motion, which was agreed to.

The retiring Directors, the Right Hon. Robert Bourke, M.P., and the Hon. E. Chandos Leigh, Q.C., were unanimously re-elected to their seats at the Board. The auditors were subsequently re-appointed, and on the motion of Sir THOMAS DAKIN a hearty vote of thanks was passed to the Chairman and Directors, and the proceedings terminated.

The Edison and Swan United Electric Light Company (Limited).

The second annual general meeting of this Company was held on Friday, the 31st ult., at the Holborn Viaduct Hotel, Holborn Viaduct, Mr. James Staats Forbes in the chair.

Major S. FLOOD PAGE (the Secretary) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN said he thought the report bore out the prediction which the Directors made at the last meeting. After carefully looking into the concern the Board came to the conclusion that a profit might be made out of it, instead of a very heavy loss. That had been carried out in their first year's working. There was nothing really so eloquent as figures after all. The accounts were for the year ending 30th June, 1885, and there was one thing they might note. Their business was now so much better organised, that they were enabled to call the shareholders together on the last day of July instead of in November, as was the case last year. This year they had got it pretty close up, because their operations being brought down to the 30th June they were able to tell the shareholders on the 30th July

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what the outcrop was. The outcrop had simply turned a loss of £28,000 odd into a profit of £12,000 odd, and he supposed that so far they might consider it as satisfactory. The balance of profit as shown by the profit and loss account was £12,353, and, subject to going through the figures a little later, he had better go on with the rest of the report, just emphasising it as a measure of the altered position of the Company, that in one year they had transformed, and transformed by legitimate means, a loss of £28,000 into a profit of £12,000, and therefore the difference was, as they would see, about £40,000 in favour of the present moment. He might at once go to the fifth paragraph of the report, which stated that they had determined that the factories at Newcastle must be given up. They were risky buildings involving not only a dangerous risk, and, as a consequence, the payment of an exceptionally high premium, but further they might involve them in even a more serious matter, and that would be the destruction of their reserve stocks. They had taken to some extent precautions to guard against such a calamity, and they had found for that and other reasons the best thing in the interests of the Company would be to transfer the factory to proper premises in the neighbourhood of London. They were fortunate enough to find premises already built in every way suitable, and at a very moderate price, and, acting upon what they knew to be the interests of the Company, they had purchased those premises, and were now occupied in fitting them up for the permanent manufacture of their lamps, so to speak, under their own eyes. Newcastle was a very long way off, and "out of sight out of mind." They thought it better to have a matter so important to their future as the efficient manufacture of their lamps under their own control, and for that purpose it was necessary to transfer the factories to or near London. Paragraph No. 6 they must take *cum grano*. They had some complaints in the early part of the year as to the character of the lamp, because lamps, like everything, did not attain perfection at once. The lamp had been subjected to a great many experiments with the view of improving it, making it more efficient, giving it longer life, greater power of resistance, and so forth, well some of those experiments, though initiated in good faith, were not altogether satisfactory, and for a short time they no doubt raised a good deal of odium for turning out a lamp which was not quite so good as it might have been. Happily, now, they had cured that evil, and they knew, as a matter of experience that the present lamps which were being manufactured and sold were a great improvement upon the preceding ones, and were, in fact, giving entire satisfaction to the consumer. At the last meeting he had occasion to dwell upon two distinct parts of their business, one was lamp making and selling, and the other was installing. Most of their grief had come about from their having rushed a little too rapidly and without sufficient knowledge (he was not talking about themselves individually, but he meant their predecessors of the two companies) into what they called installation work at rental. He thought almost without exception those installations, though initiated in entire good faith, had been attended with large loss. Anyone who undertook to light at a rental must have a very imperfect knowledge of his own interest. They determined at the last meeting—and he laid great stress upon this—that they would have no more of it, that they would not work at all on installations except for ready money, and at the risk of the gentlemen for whose benefit the installation was laid down, and eliminating all the bad things and getting rid of rentals as rapidly as they could was the policy on which they had gone. They would not now install and light people at a rental; they would only install when people were satisfied to run the risk of installation by paying for it as the work proceeded. That of course had rather diminished the volume of their business, but he had no doubt they would agree that it was better to make a large profit on a small business than to make a heavy loss upon a big one. That was exactly what they had had impressed upon them by their experience, and it was what they were hanging on to very hard and fast. Paragraph 8 followed it up by showing that as rapidly as they could they were getting out of these bad contracts. The contract with the Glasgow Post Office and at Messrs. Gartside's works had terminated through effluxion of time, and had not been renewed, and as other opportunities arose of doing the same they would avail themselves of them. The ninth paragraph of the report referred to portions of their business which he was afraid involved the Directors at all events in a vast deal of trouble and responsibility, and that was in looking after the remarkable class of people called "infringers." Of course, as he said before at the meeting last year, those gentlemen played a waiting game; they hung back until some invention of great value was taken by the public, and then they came, and under one pretext and another, they tried to intervene between the man who had generated it and who should receive the profits. There were a good many of these persons, but the most persevering were Messrs. Woodhouse and Rawson, who were under injunction, and had been for a very considerable time. They were keeping an account of the lamps Messrs. Woodhouse and Rawson manufactured, and an action against the firm had been pending for a considerable time. He hoped it would be tried in November. He was afraid they could hardly escape, like other great inventions, the test of legal validity, but as far as they were advised they had every reason to believe they would succeed. If those infringers thought it worth their while to go to the test of action, the shareholders must rely upon the Directors doing their best in the matter. They were well advised, and had pretty nearly the same brains and technical skill behind them as the telephone company had had when they had to fight their telephone patents, which they had done, under the presiding genius of their Chairman, with uniform success. The tenth paragraph of the report dealt with provisional orders. That was a very old story. Everybody at first was a little mad about electric lighting; they certainly were who were induced to give such enormous sums in money and shares for the privilege of working out these patents; but they were no madder than the rest of the public, and certainly not as mad as those who were called the local authorities, vestries, and others who thought it such an immense thing that they attached the great privilege of supplying light to them at a probable heavy loss to the contractor. The public authorities having in mind what they regarded as the parallel atrocities of the gas companies and the water companies, who, like themselves, having to initiate the supply of an article of daily necessity, after they had taken all the risk of doing it on express contract, were thought to be the most grinding people in the world because they wanted the contract fulfilled, attached such enormous conditions in the way of penalties, and took such exceedingly good care of themselves in the event of its turning out successful, that they managed to enlist on their side the Board of Trade, for whom he had the greatest respect, and who, he was bound to say, acted in entire good faith, on evidence, and listened to everybody. It was very popular, the theory of laying hold of the results of other men's brains and enterprise when it was possible to do it by evading contract. It was rather sad, but it was very common. Well, happily this company and others had had the scales fall from their eyes in respect to the Electric Lighting Act, and the gentlemen of the vestries and others were very like the people who killed the goose that laid the golden eggs, because their conditions and obstructions had been so entirely effectual that there was really no electric lighting in London—what they called central station lighting—nor did he think there was likely to be on any large scale, because he could not imagine any body of men now being so entirely denuded of common sense as to go into any electric lighting on the terms of the Electric Lighting Act, and, therefore, it was a dead letter. He had himself attended one or two deputations to the Board of Trade. The late right hon. President of the Board of Trade (whatever his political qualities, which he was not going to discuss) was certainly one of the best men of business he had ever met there. He had done business with the Board of Trade for forty years with all sorts and conditions of men as president, and he had never met a more courteous or able man, a man who could so readily grasp the ins and outs of questions submitted to him as the right hon. gentleman from Birmingham. He thought Mr. Chamberlain had been persuaded that this Electric Lighting Act wanted a great deal of amendment and modification. Until it was so modified he (the Chairman) ventured to predict that there would be no electric lighting done under it. This company certainly would not do it. They had better stick to their lamp, and to those installations which they could accept if they pleased, and which, having installed, they were done with, and they were not liable, as the Electric Lighting Act proposed, to have them left on their hands if they did not pay, and to have them taken from them if they did. In Paragraph 11 there was a sort of declaration of policy that they were not going to cut the throats of other companies or firms; that was to say they were not entering into unprofitable rivalry with other companies. They proposed to go on steadily. They thought they had a very good business, and that the year past was only an indication of what was to come. Of course, one could not shut one's eyes to the possibilities of what electric lighting might become. He was told that private lighting was extending enormously, and no doubt every day it would develop, and he thought if they were wise they would go on steadily waiting, availing themselves of all opportunities and extending their business on the theory of making a fair profit out of it. There was an appeal to assist the Directors in endeavouring to obtain installations and orders for lamps. He did not know that such appeals to shareholders were of much good, but he hoped they might be in their case. He thought they were deserving of consideration. He was told that fire insurance companies and other kindred institutions had got a good deal of business through their shareholders, and therefore they took the liberty of telling those present and those who might read the report of these proceedings that they might do them some good, first of all by themselves lighting up and then by urging on their friends the enormous advantage which they would experience when they had adopted the use of the electric light. That was the end of the substantial part of the report; but perhaps he had better take them through the balance-sheet. The accounts were very simple; it did not want much knowledge of figures to master them. If they looked at the debtor side of the balance-sheet they would see that the share capital remained as before. There had been no change there; it was practically the same, £353,478. Then there were "B" shares to be issued, those representing Mr. Edison's contingent interest in the value of this concern after the ordinary capital had divided a cumulative dividend of 7 per cent. per annum. Well, at the present moment that did not appear to be what they might call very proximate; but he thought that even Mr. Edison might keep up his spirits, although he had to clear away a great deal before he arrived at the contingent to which he was entitled for his inventions. With regard to the creditors, they had diminished them from £19,937 to £11,769. The last and most satisfactory element in this balance-sheet was the profit and loss balance of account for current year, £12,353, against not only *nil* last year, but as he had said before, a balance of loss of £28,000. Then, on the other side of the account, they would find the first post, £300,988. 7s. 7d., remained the same. Further expenses thereon since, £10,821; that was the amount of their capital they had taken the liberty of spending in different ways during the current year, extending their business, works, and so forth. Then they had released a quantity of old plant, embraced in the first post "Cost of patents, preliminary outlay, loss on working, &c." which involved certain elements which might or might not turn out to be dead loss—not wholly so. They had realised useless or other plant, which was not necessary for their purposes, £6,753; therefore the post stood net at £305,057. The freehold property had increased somewhat. They had made some additional purchases, partly on account of the permanent factory which he described early in the meeting. The installations in progress had diminished somewhat, from £6,100 to £2,000. That showed that they had not as much money locked up in installations as they had this time last

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year. Plant and stock £28,850 ; that had rather increased. They had rather a larger amount of lamps in hand, lamps and other materials, as they would see by reference to the profit and loss. They began on the 1st of July, 1884, with £13,900, and had £19,384 on the 30th June, 1885. The furniture at London and Newcastle was £1,054. The debts, which were £32,142 in the last balance-sheet, were now £19,000. They believed them to be sound and good. Cash at the bankers and in hand was £12,896. Carrying them down to the profit and loss, which really, after all, was the material part, there was, "By sales of lamps, fittings, &c., and charges for work done," £80,925. 17s. 9d. ; last year it was £98,285. 11s. 9d., but, as he had told them, their business was to give up two classes of business—doing installation work at a loss, and to retire as soon as possible from the working of other installations upon which not only was there the first loss on what they might call the sunk capital, but the loss in working from day to day. It was to the elimination of those two bad parts of the old business they owed the compression in the volume of work from £98,000 to £80,000. The balance of interest and discount account and transfer fees was £242, and the stock on June 30 was £19,384. They were obliged to keep on hand a very large stock of lamps in anticipation of orders, and it had been thought desirable to increase rather than to diminish the stock in view of the slight disarrangement which would take place in removing the factories. They were manufacturing in anticipation of orders, so as to save during the transition period. Most of the stock consisted of lamps, but there were other things, such as dynamos, and others which he need not mention. The result was a total of £100,552, against £140,502 last year, including £28,000 of loss. On the other side of the account the stocks on hand were £13,943. He did not know that he had much to say about wages, &c.—£56,000 as compared with £75,000. Then the salaries, Directors' fees, and so forth, were £15,078, less £750 waived by Directors. The new Board of Directors thought it advisable to put themselves in the same boat with the rest of the Proprietors—at all events, for a time. Then there was salary to Mr. Swan, that was under the original contract, and the depreciation of plant was £1,928, against £2,302. It was a lower figure of course, because a good deal of the value of the plant had been written off in the last year's account. The balance, being profit, was £12,353. 15s. 9d. He should be very happy to give any further enlightenment on these figures if any proprietors wished for it. He thought the figures justified what he had said at starting that they really had carried out their pledges to the proprietors, that they were not deceived in considering that this business had really a substantial foundation, and that as soon as early errors were corrected and they put themselves upon the ground of conducting business on the theory of making profit it would be a good property. The Directors recommended them to carry the profit forward, as they wanted to make this a sound property in the future. In conclusion, the Chairman moved that the report and accounts be received and adopted.

Mr. LEYLAND, in seconding the motion, said the losses they had previously suffered from arose really from an inheritance of bad business that they could not get out of. There were contracts which they were bound to carry out.

Mr. ADDISON asked if the amalgamation of the two companies had been carried out.

The CHAIRMAN replied that the amalgamation had been carried out, but the foreign business of the Swan Company, as originally intended, would be carried on separately.

A SHAREHOLDER would like to know if any of the takers of the installations had continued the lighting and purchased the plant, or whether the Company had removed the plant. He thought that would throw some light on the advantage to be derived from the use of the electric light in the eyes of the hirer.

The CHAIRMAN replied that as far as the Glasgow Post Office was concerned they were continuing it under some arrangement with some other firm—he did not know who. At Messrs. Gartside's works they had given it up, and the Company had removed the plant. At Holborn Restaurant, which was one of the most important installations, it was in a transition state, but that would no doubt end in Mr. Gordon buying their plant, and carrying it on on his own account. The contract with Gatti's was not up yet.

A SHAREHOLDER asked if the lighting of Victoria Station had been satisfactory, and if it was now carried on by the Chatham and Dover Railway Company.

The CHAIRMAN replied that the Victoria installation had not yet been transferred to the Chatham Company. He meant to say that it had not yet attained that pitch of perfection which was promised by the gentleman who was good enough to install it for them, and although the Chatham station had been lit for some time, the installation had not yet been taken over by the Chatham Company.

A SHAREHOLDER asked what were the probabilities of the Chatham Company taking it over.

The CHAIRMAN replied that if the installation fulfilled the conditions of the contract it was exceedingly likely they would take it over—that was to say, they would pay a consideration if they got the light ; but he did not think they intended to take over the installation itself, which was an installation erected not only for the Chatham Station, but for the whole of the surrounding neighbourhood. There was no rule without an exception, and that did appear to be a place where the experiment of a central station might be developed, because there was abundance of capacity there. There was the Brighton Station, the Underground Railway, the Grosvenor Hotel, and a number of works, all of which could be got at without interfering with the public streets.

The report was then adopted, and the retiring Directors and Auditors having been re-elected, a vote of thanks to the Chairman and Directors terminated the proceedings.

Anglo-American Brush Electric Light Corporation.

The following is the report of the Directors :—

Nearly six months having elapsed since the last general meeting, the Directors feel it will be a satisfaction to the proprietors to learn that business continues steadily to improve, and that there is substantial evidence that the high quality of the electrical apparatus manufactured by the Corporation is now fully recognised and appreciated. The business effected during the past half year compares favonrably with the result of the operations during the corresponding period of last year, and the present position of finance would enable the payment of an interim dividend. The experience in past years shows, however, that there is some degree of uncertainty as to the maintenance of the same average volume of business during the autumn months, and the Directors have decided, after careful consideration, that the interests of the shareholders will be best served by carrying forward the profits realised on the working of the last half year, rather than by the payment of an interim dividend to take up a position which might lead to disappointment when the accounts of the whole year come finally under review and adjustment. It is much to be regretted that the Electric Lighting Act of 1882, which has so greatly impeded the progress of electric lighting, is still unamended. The recent change of Government has interrupted the negotiations, which had been initiated with much care and consideration, with the view of obtaining an early amendment of the Act, and it is not probable that anything can be done until after the General Election. The matter, however, is receiving the constant attention of your Board and of the committee of experts and representatives of the leading companies formed to watch over electric lighting interests, and to confer from time to time with the Board of Trade. It is now generally admitted that considerable modifications in the Act are required both in the interests of the public who desire the light, but are unable to obtain it under the existing repressive restrictions, and of those whose business it is to make such supply a commercial possibility. Sufficient proof has now been afforded of the practicability and advantages of the electric light, and the outlook may be considered as most encouraging so soon as the more equitable conditions, which must be eventually conceded by Parliament, have been established.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. AUG. 5.		BUSINESS DONE WEEK ENDING AUG. 5. Highest.	Lowest.
Anglo-American	29,	30	30½	29½ x d.
Do. Preferred	50,	51	52	48½ x.d.
Do. Deferred	8,	9	8½	8½
Brazilian Submarine	11,	11½	11½	—
Cuba	11¾,	12½	11¾	— x.d.
Do. Preference	17½,	18½	—	— x.d.
Direct Spanish	1½,	2	—	—
Do. Preference	12,	12½	—	—
Direct United States Cable	8½,	9	9½	9 x.d.
Eastern Telegraph	11½,	11¾	11 11-16	11½
Do. 6 per Cent. Preference	13½,	13¾	13½	—
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12¾,	13	12 15-16	12¾
German Union	9½,	9¾	—	—
Globe Telegraph and Trust	7,	7¼	7 3-16	6¾ x.d.
Do. Preference	12¾,	13	13	12 13-16x.d
Great Northern	13¾,	14	14 3-16	—
Indo-European	30½,	31½	—	—
Reuter's	7½,	8	—	—
Submarine	180,	190	194½	192½ x.d.
West India and Panama	⅜,	1	⅜	—
Do. 1st Preference	8½,	8¾	8¾	8½
Western Brazilian	6½,	6¾	—	—
Western Union 7 per Cent. 1st Mortgage	120,	124	—	—
Do. 6 per Cent. Sterling Bonds	103,	105	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅛,	¼	⅛	—
Oriental	⅛,	⅛	—	—
United Telephone	11,	11½	11¾	11¾

ELECTRIC LIGHT.

Anglo-American Brush Light(£3 paid)	1½,	2	—	—
Do. (fully paid)	3½,	3¾	—	—
Hammond Light (£3 15s. paid)	⅛,	⅜	—	—
Swan	½,	¾	—	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	87,	88	87½	87
India Rubber, Gutta Percha, and Telegraph Works	24,	25	24¾	24¾ x.d.

TRAFFIC RECEIPTS FOR JULY, 1885.

COMPANIES.	July, 1885.	July, 1884.	Increase.	Decrease.
Cuba Submarine	2,500	£3,219	—	719
Direct Spanish Telegraph	1,260	1,501	—	241
Great Northern	25,200	—	—	—

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NOTES.

A NEW TELEPHONE EXCHANGE.—A new telephone exchange is to be opened at Reading, Berks.

THE EARTHQUAKES.—A shock of an earthquake has been felt at Booleroo, in South Australia.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ending July 31 amounted to £3,325.

UNDERGROUND WIRES IN CHICAGO.—The work of placing the electric light, telephone, and telegraph wires underground in Chicago is proceeding rapidly.

THE NEW PAVILION MUSIC HALL.—We understand that the Edison-Swan Company are to have the electric lighting of the new Pavilion Music Hall in Tichborne-street.

THE EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of July amounted to £48,081, and £50,072 in the corresponding period of 1884.

ELECTRICIANS IN LIQUIDATION.—We note that Paget Higgs (Limited), some time carrying on business as electricians at 58B, Rose-street-lane South, Edinburgh, are in liquidation.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of July, 1885, were £1,260, against £1,501 in the corresponding period of last year.

THE ELECTRIC LIGHT IN MINES.—We are informed that the Ashington Coal Company are about to have the electric light adapted to the requirements of their extensive colliery near Newbiggin, Northumberland.

THE GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this company are as follow:—Receipts for July, £25,200; 1st January to 31st July, £168,040; corresponding months, 1884, £155,880; 1883, £145,640.

THE EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of July amounted to £46,099, and to £40,870 for the corresponding period of 1884; increase, £5,229.

50,000 CANDLE-POWER.—One of the largest single electric lights ever constructed was placed on exhibition at Seneca Falls, N.Y., recently. It was of 50,000 candle-power, was made in Ilion, and is intended to illuminate the whole village.

THE ELECTRIC LIGHT IN LIEGE.—M. Jaspar has made an offer to the Municipal Council of Liège to install the electric light in the Theatre Royal in that town. The tender, which includes an engine of 40 horse-power, amounts to about £800.

WELL DESERVED.—We are glad to note that M. Trouvé has obtained a silver medal at the International Inventions Exhibition for scientific research. Probably no living inventor has contributed more variously to electrical science than this eminent French electrician.

A NEW CONTEMPORARY.—A new French scientific has been brought out under the title of *La Science Universelle*, M. H. Graffigny being the editor. The issue forwarded to us is a very interesting one, and our new contemporary should command a fair share of success.

A NEW MEDICAL GALVANOMETER.—Gaiffe's new medical galvanometer contains but one needle and has no directing magnet. Correct proportion between the current strengths and deflections is obtained by means of a special form given to the frame upon which the wire is wound.

UNDERGROUND WIRES IN NEW YORK CITY.—The commissioners on putting electric wires underground in New York City have elected Charles E. Loew president, and Theodore Moss secretary, and have requested the companies to submit maps, plans, and methods within sixty days.

NARROW ESCAPE.—During a thunderstorm lately at Benares, the electric fluid passed right through a room in one of the barracks in which several men were present, but without doing any harm, and fell in the roadway, ripping up the earth for about thirty yards, and making a hole of about four feet in depth.

THE ADMIRALTY AND THE ELECTRIC LIGHT.—The necessary arrangements are now being made at Chatham Dockyard for lighting the workshops and factories with the electric light, the results of the trials carried out for some past in those of the workshops already lighted by electricity having been found to be satisfactory.

THE EDISON SYSTEM ON BOARD SHIP.—According to a recent list of the Edison Company we notice that no less than 46 vessels have been fitted with this system, with a total of 7,805 lights. The largest number of lights on board any one vessel is 920, this being the number installed in the "Pilgrim," belonging to the Fall River Line.

THE CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of July was 3,058, estimated to produce £2,500, against 3,596 messages, producing £3,219, in the corresponding month of last year. The traffic receipts for the month of April, estimated at £3,700, realised £3,886.

SIXPENNY TELEGRAMS AND REGISTERED ADDRESSES.—In the House of Commons on the 7th inst., Mr. King-Harman asked the Postmaster-General whether under the Telegraph Acts Amendment Bill any alteration would be made in the existing system of registration for addresses for telegraphic purposes. Lord John Manners was understood to say that no alteration would be made.

THE SOUDAN TELEGRAPHS.—Our contemporary, the *Military Telegraph Bulletin*, is informed that the line from Cairo to Halfa is in a very rotten condition., all the wooden poles being ant-eaten to the very summit. It seems a wicked waste, says the *Bulletin*, to abandon all the Siemens iron poles between Halfa and Debbeh, but the army is short of transport as it is, and iron poles won't float.

THE ANTWERP EXHIBITION.—On the 30th ultimo, the Central Gallery and the Machine Hall were for the first time electrically lighted. In the Electrical Section *diplômes d'honneur* have been awarded in the following order:—1. Telegraphs of the Belgian State; 2. Gaston Planté; 3. Mourlon and Van Rysselberghe; 4. Société Générale des Téléphones de Paris; 5. Schubart, of Ghent; 6. Compagnie Générale d'Electricité, of Brussels; 7. J. Jaspar, of Liège.

TECHNICAL EDUCATION.—The Saddlers' Company have established four studentships, each of the annual value of £30, and tenable for two years, at the Finsbury Technical College of the City and Guilds of London Institute. The studentships will be competed for at the entrance examination to be held at the College on Oct. 1, and are open to pupils above 14 years of age who are attending, or who have attended, any public elementary school in the United Kingdom.

THE AMERICAN TELEGRAPH COMPANIES.—The Baltimore and Ohio Telegraph Company replies vigorously to Mr. Jay Gould's stories about its being bankrupt. The Bankers and

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Merchants' Company have reorganised, in a promising manner, as the United Lines Company of Land and Ocean. The rivalry of the Western Union Company appears to increase. It is surmised that the competition between the Cable Companies is one reason of Mr. Jay Gould's anxiety to control the chief competitor.

THE NATIONAL ARTILLERY ASSOCIATION AT SHOEBURYNESS.—The telephone is again this year in operation between the scoring parties at the ranges, the batteries, and the statistical office in camp. The postal and telegraphic arrangements are on the same scale as before. A special tent is pitched in the camp, to which a wire is laid from the local post office, and a staff from the telegraph office has been sent down to work it with punching instruments and Wheatstone transmitters, so that no delay is experienced in getting off even the longest messages.

THE TELEGRAPHS IN BRITISH NORTH AMERICA.—In the annual estimates submitted to the Dominion Parliament the following provisions are made for the extension of the telegraphs of the country :—"Telegraphic communication between Amherst Island, Bay of Quinte, and the mainland at Bath, 1,500dols.; reconstruction of line between Battleford and Edmonton, *vid* Fort Pitt, additional amount required to complete, 20,000 dols.; land line on north shore of St. Lawrence between River Pentecost and Mingan, to complete, 500 dols.; Grosse Isle quarantine telegraph, 2,150 dols.

THE TELEPHONE IN FRANCE.—Public Telephone Exchanges are now in actual operation at the following places in the north of France :—

Lille	146	subscribers.
Roubaix (interior)	163	„
„ (exterior)	4	„
Tourcoing (interior)	105	„
„ (exterior)	8	„
Dunkerque	88	„
Armentières	12	„
Halluin	10	„

CABLE COMMUNICATION IN THE WEST INDIES.—The chairman of the West India and Panama Telegraph Company has forwarded a letter praying the Court of Policy of Demerara to reconsider its decision in ordering a certain amount to be deducted from the subsidy of the company on the ground that direct cable communication had been interrupted for a considerable time. The Court understood the company simply petitioned the Court for a reconsideration of the matter, and that there was no question raised as to the power and right of the Court to deduct the sum. The matter was therefore ordered to stand over for further consideration.

THE UNITED TELEPHONE COMPANY.—The United Telephone Company have issued a circular giving notice that they are now prepared to afford certain important facilities for the transaction of business to their customers. The payment of a special £12 rate will enable subscribers to talk from their own houses to the principal shops, clubs, theatres, &c. An arrangement has been made with the General Post Office whereby subscribers will be able to despatch from, and receive at, their own offices telegrams direct to and from any part of the world. The directors contemplate establishing a complete network of public telephone rooms in London and the suburbs.

THE RECKENZAUN ELECTRIC TRAMWAY IN BERLIN.—The preparations for this line, which leads from the centre of the town into the Ausstellungspark, are in active progress, and it is expected that the line will be opened for traffic by the end of this month. The first experimental car has been built by Messrs. Herebrand, of Cologne, and is being fitted with motors and gear made by the Electrical Power Storage Company, under Mr. Reckenzaun's directions. The accumulators are made by Epstein in Berlin, and in regular service they will be charged from the electric light circuit already existing in the palace of the exhibition. Herr F. Zacharias is the engineer to the company.

AN ELECTRICAL YACHT.—There is now being constructed at Mr. Skelton's yard, Millwall, a small yacht, which will be propelled by electrical power. The boat is 36ft. in length by 7ft. in breadth. It is constructed of galvanised steel, lined inside with wood and lead. The accumulators are placed below the floor of the boat, so that with the exception of a small compartment aft for the dynamos, the whole of the space is available for passengers. Two masts and a full suit of sails are also fitted for use when required. In the course of a few days it is intended to take the yacht on a trial trip from Dover to Calais, when it is fully anticipated that a good speed will be obtained.

THE ELECTRIC LIGHTING OF TRAINS.—On the occasion of their visit to Lincoln the members of the Institution of Mechanical Engineers witnessed, on the 7th inst., the trial of an electric lighting experiment by Mr. Oakley on the Great Northern Railway. A train was run by that gentleman from Lincoln to Grantham, which had on board an arrangement whereby the carriages could be lighted by electricity, with switches and storing accumulators, by which the light could be regulated when the train stopped. The members then proceeded to Gainsborough, and visited Messrs. Marshall and Co.'s Works, where nearly 2,000 men are employed in the manufacture of agricultural and other machinery. These works are now partially lighted by arc lamps of 3,000 candle-power.

TELEGRAPHIC COMMUNICATION WITH AFGHANISTAN.—It has been pointed out—and the suggestion is well worthy of attention—that the Ameer should be moved to consent to the immediate extension of the telegraph to Candahar and Herat. The difficulty of making a line would not be great. A strong ruler like the Ameer could guarantee its safety, and the Indian Telegraph Department could easily train a staff of Mahomedan clerks, whose presence would neither alarm nor irritate the Afghans. Such a line, besides being of the greatest use politically and strategically, would probably soon command a large commercial traffic, for during the British occupation of Candahar the merchants of that place were not slow to learn and avail themselves of the use of the wire. Moreover, when the line was once made to Herat it would be easy to connect it with the Persian system from Meshed and Russian Sarakhs, thus giving a new route between India and England.

ELECTRIC LIGHTING OF BUCKINGHAM PALACE.—It is not often that the perusal of the columns of the gas lighting journals are productive of much that is either interesting or reliable in so far as electricity is concerned. Last week, however, in a weak moment, and with a misguided belief in the possible truthfulness of a contemporary, a paragraph was allowed to creep into our columns relative to the alleged electric lighting of Buckingham Palace on the occasion of a State ball. That paragraph was absolutely incorrect. Buckingham Palace, as many of our readers will be aware, possesses a fixed installation, under the able superintendence of Mr. W. H. Massey, of Twyford, Berks. This comprises one 500-light Siemens dynamo, two 400-light Crompton machines, and one 350-light Victoria, running over 1,000 incandescent lamps of various kinds. The dynamos are driven by Willan's engines, fitted with the electrical governors of the same maker.

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THE ELECTRIC LIGHT IN NEWSPAPER OFFICES.—The publishers of the *Courier*, of Evansville, Ind., have written as follows to the New York *Electrical World*:—"We have a 30-light United States plant in our office, which we put in about the 1st February. For the benefit of newspaper publishers we wish to give a statement of what the cost has been to us, and how much can be saved by using the incandescent lamps in place of gas. We had a good engine and boiler, and hence had no expense in putting in plant, except cost of dynamo, wires, wiring, and lamps. Our coal bill has been increased 10dols. per month. Cost of lamps (600 hour guarantee) 15dols. per month, attendance 15dols. per month, making total cost of 30 lights (we have 36 in, but do not use them all at any one time), 40dols. per month. Gas at 2dols. per 1,000 would cost from 80dols. to 100dols. per month. Coal oil, including breakage of lamps and chimneys and attendance, had been costing us over 35dols. per month. So publishers who have the power will find the incandescent lamp the best and cheapest."

THE INCANDESCENT LAMP A BELGIAN INVENTION!—Our excellent contemporary, the *Journal de Bruxelles*, which is nothing if not patriotic, puts forward on behalf of M. Léon Somzée a claim to priority in the invention of the so-called "Edison" incandescent lamp. The patent of M. Somzée, says our contemporary, which is identical with that of Edison, was taken out on the 5th of November (auspicious date), 1879, at which time the invention was completed, whilst the Edison initial patent was not granted until the 21st of November in the same year. A second patent, having reference to the form and resistance of the carbon, dated from the 30th of December. It was, then, in the fertile brain of M. Somzée that the incandescent lamp had its origin. Messrs. Swan and Edison are deserving of thanks perhaps for bringing the thing to a practical and successful issue, but that's nothing—nothing at all. The only fact that we are to be lost in admiration of is, that "C'est à un Belge qui revient la gloire de l'invention de la lampe à incandescence." Strange to say M. Léon Somzée is the representative of the gas industry in Brussels!

SERIOUS ACCIDENT.—A Newry telegram reports a serious accident on Friday evening on the Bessbrook and Newry Electric Tramway. During the week experiments had been conducted with a view to testing the electric machinery, and on Friday evening Mr. Davis, J.P., estate agent for Mr. Richardson, M.P.; Mr. Edmund Davis, his brother; Mr. Harrison, the manager of the line; and James Williamson, the engineer, started in a passenger car from the Bessbrook Junction for a trial trip to Newry. About half-way between Bessbrook and Newry there is a very sharp decline, and when the car had reached this point the electric power was cut off and word given to put on the brake; but from some unexplained cause the apparatus did not work, and the car dashed down at a terrible rate. On reaching Craigmore it was seen that two empty goods trucks were standing on the line about half a mile ahead, and the occupants of the car recognising that if they remained where they were they would meet with certain death, jumped out and were hurled on to the line with terrific force. Mr. William Davies was thrown on his face and rendered unconscious, Mr. Edmund Davies sustained severe injuries, and the driver was thrown on his head and cut severely. The car rushed on and, striking the trucks, threw one on the other and both off the line.

THE WHITWORTH SCHOLARSHIPS.—The following candidates have been successful in the competition for the Whitworth Scholarships, 1885:—Scholarship of £200: T. Clarkson, engineer, Manchester. Of £150: H. O. Bennie, engineer, Glasgow; R. H. Unsworth, engineer, Pendleton, near Manchester; H. M. Martin, engineer, Gateshead; W. T. Calderwood, mechanical draughtsman, Glasgow; J. Richards, blacksmith, Cardiff; E. R. Dolby, engineer, Leeds; J. Rorison, engine fitter, Paisley; A. J. Moulton, engineer apprentice, Preston. Of £100: W. M'Neill, mechanic, Birmingham; G. W. Moreton, fitter, Crewe; S. E. Mallinson, assistant analyst, London; H. C. Jenkins, engineer and millwright, London; R. Smith, engineer, Glasgow; T. W. Nash, engineer, London; H. F. W. Burstall, engineer apprentice, London; J. Stopher, mechanical engineer, Nottingham; S. H. Wells, marine engineer apprentice, London; G. Milnes, fitter, Charlton, Kent; H. Begbey, engineer, Old Charlton, Kent; J. Goodman, engineer, Brighton; M. H. Crummie, mechanical engineer, Hull; O. Marsh, fitter and turner, Crewe; T. Galbraith, pattern maker, Manchester; J. H. Bowles, engine fitter, Stratford. The College of Science and Arts, Glasgow, has again secured the best position in Scotland in regard to the competition for the Whitworth Scholarships, H. O. Bennie being second, and William T. Calderwood fifth, both trained there for four years, while James Rorison, eighth, and Robert Smith, fourteenth, were also students of this College for one and two sessions respectively, and last year of Anderson's College.

THE ELECTRIC LIGHTING ACT.—In the address delivered recently by the Earl of Pembroke before the Liberty and Property Defence League, and published in the current number of the *National Review*, the following reference is made to Mr. Chamberlain's attempt to legislate for electric lighting on Socialistic principles:—"In the last generation men who risked their money in enterprises which, if successful, would benefit the public, were looked upon as public benefactors, and encouraged. Now they are looked upon as public enemies—as Shylocks who use their legal rights to plunder the public, and against whom, therefore, any spoliation that is legal is fair. The benefits they confer, the risks they run, the failure of other capitalists, less skilful or less fortunate, are all forgotten; nothing is remembered but their bitterly grudged profits. Water companies, railway companies, lighting companies, are looked upon as burdens rather than benefits. To take one instance out of many. I read in *The Times* a few months ago that those interested in electric lighting went as a deputation to the President of the Board of Trade and pointed out to him that the progress of electric lighting had been stopped by a provision of Parliament to the effect that the public should have the right to take over the property of any public electric lighting company at the end of twenty-one years, at a certain price. The childish simplicity of the idea is more worthy of the dark ages than of the nineteenth century. The companies were to take all the risk of failure, and in the event of success were to be deprived of the profits. As a natural consequence public electric lighting is at a standstill. Could anything be more foolishly shortsighted? Could there be a more absurd instance of the policy of killing the goose that lays the golden eggs?"

A NEW ELECTRIC RAILWAY SIGNAL.—In a new system of automatic railway signals, a train moving over a line protects itself both in front and in the rear automatically, and sends a signal to two posts beyond the one at which it is situated. From that point a signal is sent back to the first point beyond the train, and the signal is set at that point. If the train ahead has not left the block, the signal will not be sent back, and when the train arrives at the post it will find the signal at danger. If the block is clear, however, the signal will be sent back and will set the

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disc at safety. In point of fact, the second post in advance notifies the first post in advance that it is safe for the train to proceed. In the same way, while signalling forward, the train also signals to the rear, and thus sets the signals for the train following. The mechanism includes a small motor for turning the signal disc, and the latter is fitted with an electric lamp which enables the trainmen to see it at night. This lamp at each post is in a normally open local lighting circuit, and is so connected that a current will be diverted through it, giving a light at the approach of a train. The switch by which the connections are controlled is operated by the movement of the signal mechanism. As soon as the train passes, however, the signal disc turns again, operates the switch, and extinguishes the light. Thus the waste of electric energy is prevented and the lighting circuit being entirely local, any accident to it will not affect the operation of the main circuit. The signals are all automatic, no clockwork being used. The motor, actuated by a current from a local battery, turns the signal disc in the proper direction. While entirely automatic in its operation, the mechanism can be operated by hand, and thus in case of necessity a railroad *employé* provided with a key could set the instrument and transmit signals accordingly. Mr. W. T. Waters, of Atalanta, Ga., is the inventor of this ingenious apparatus.

Reducing Salary by Telephone.—A Paris tenor singer of repute and an electrical friend, says the *Electrical World*, visited the recent electrical exhibition at the Observatory, and inspected the telephone. The tenor wished to talk with his manager. The friend busied himself about the apparatus, "to establish the connection," as he said, and then retired, not wishing to hear the conversation. But as a matter of fact he entered a private cabinet with which he had connected the wires. "Can I have a word with you, Monsieur le Directeur?" inquired the tenor. "Certainly," answered a distant voice. "It gives me such pleasure that I am able to converse with you at this distance. What's the news?" The voice replied, "That you are fast losing your voice and have lately been singing dreadfully out of tune. You are no longer a tenor, but a veritable hurdy-gurdy!" "I must have misunderstood you," observed the singer in the greatest alarm. But the extraordinary statement was repeated, with the addition: "You will plainly see that I cannot go on paying you the same salary. If you are willing to stay on for half——" The tenor, flushed and excited, ran out of his cell and down the steps, and called for a cab to take him to the address of his manager. He did not stop to say good-by to his friend who stood watching him and laughing aloud. A few minutes later the tenor stood before the manager. "I am willing to stay for two-thirds of my former salary, but let me tell you one thing—my voice isn't a hurdy-gurdy. You understand?" "To be sure," said the manager, who thought this member of his company had gone out of his mind. "You know how greatly I prize your voice, and especially now that you are reducing your claims. I am greatly obliged for your spontaneous offer." "Spontaneous offer?" exclaimed the bewildered artist; "when you wanted to cut down my salary by half . . . through the telephone! That confounded invention. . . ." The manager saw that a trick had been played on the unsuspecting tenor, and is said to have declined acceptance of the proffered reduction.

Heavy Thunderstorms.—The West Berks district was visited by several terrific thunderstorms on Friday. The first occurred at about two o'clock in the morning, when the flashes of lighting were frequent and vivid, and the peals of thunder particularly loud. A second storm commenced shortly before midday; but the most serious storm broke over the district in the afternoon.—A heavy thunderstorm prevailed in the neighbourhood of Aylesbury on Thursday and Friday, accompanied by torrents of rain. In Hartwell Park, nineteen sheep belonging to Mr. Lee, which had taken refuge under a tree, were struck by lightning. Sixteen were killed on the spot, and the other three were so injured that they had to be slaughtered. A fireball fell on Hartwell Vicarage lawn during a flash of exceptional vividness and a terrific thunderclap. In other parts of the district injury has been done, Some farm premises at Tring were struck. —At Melton Mowbray two houses were struck by lightning. One, occupied by Mr. Robinson, a solicitor, in which three rooms were partially wrecked, and the other the shop of Mr. Smith, a jeweller.—One of the most terrific hailstorms ever experienced in Warwickshire visited the Bedworth district on the same date. Thunderstorms, accompanied by vivid flashes of lightning and torrents of rain, also prevailed in this district at intervals during the day.—At Leamington a Mrs. Rouse was struck by the lightning, and rendered blind.—North Lincolnshire also suffered severely; and at Sheffield, whilst the storm was at its height, a main sewer in one of the hilly parts of the town burst with a loud report, tearing up the roadway for a number of yards and flooding houses and shops on both sides of the road. The water in the street was several feet deep. Damage amounting to £1,000 was done. A sewer in another part of the town also burst.—A heavy thunderstorm also raged over Birmingham. Two houses in the occupation of persons named Daly and Downing in New Summer-street were struck with lightning, the chimneys being knocked through the roofs and other damage caused. Two or three persons narrowly escaped death.

New Books.—"Once a Month," a magazine for Australia (Griffin, Farran, and Co., London), is a readable monthly on orthodox lines. The specimen copy forwarded to us is well written, well printed, and fairly well illustrated. It compares very favourably with other publications of its kind.—"Alphabetical Time Tables" between London and all parts of the United Kingdom and Ireland (Wyman and Sons, London). This is a penny guide; evidently an imitation of the well-known "A B C," but very inferior to it in point of general handiness. We hold that nothing is cheap unless it does all that is required of it, and this the penny alphabetical table does not do. The section devoted to "London Environs" is palpably incomplete, and although in a later edition we may reasonably look for an improvement in this direction we hesitate to recommend the subject of our review to those who are in search of an exhaustive guide to the railway system of the United Kingdom.—"Magnetic and Electrical Laws," by E. Hurren Harding (London and Glasgow: William Collins, Sons, and Cox). This is a sixpenny *brochure*, intended chiefly for the use of students preparing for examinations under the South Kensington Science and Art Department. It is very properly not put forward as a substitute for existing text books, but as a collection and condensation of useful truths, or of notes which may serve for the foundation of lessons, it will be appreciated by many. Besides the general laws of magnetism, the relation of electricity to magnetism, induction, laws of strength of charge and discharge, Ohm's law and its variations, Joule's laws, &c., the little work contains some excellent notes upon chemical action, thermo-electricity, the effects of heat, mutual action of currents, and some miscellaneous information upon various subjects connected with electrical science.—*Received:* "Electrolysis," a practical treatise on nickelling, coppering, gilding, silvering, the refining of metals, and treatment of ores, by means of electricity. By Hippolyte Fontaine. Translated from the French by J. A. Berly, C.E. (London: E. and F. N. Spon.)

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LIGHTING OF THE AUSTRALIAN HOUSES OF PARLIAMENT BY ELECTRICITY.—The Australian Electric Lighting Company, says a contemporary, were engaged during the recess in introducing the electric light into both the Assembly and Council chambers and their approaches. The work, which was carried out under the personal direction of the company's manager (Mr. Josephs), was practically finished early in June; and, according to the latest advices received, it was to be publicly tested for the first time on the reassembling of the House on the 16th of that month. The present scheme is not intended for all parts of the building, as in the reporters' rooms, domestic quarters, &c., the use of gas will be continued. In accordance with the wishes of the Parliamentary Buildings Commission the company submitted two tenders. The first provided for five groups, which comprised the number of arc lights required for the exterior of the building; and the contract price, including the extension of the installation to all parts of the building, was about £7,000. The second tender contracted for fittings for only four groups of the building; but it was stipulated that the motive power to be supplied under the contract should be sufficient for five groups. The price named in this contract was about £5,600; and the tender was accepted on the understanding that the company should, if required, extend the installations to the fifth group at the price stated in the first contract. There are two 20 horse-power engines which drive two dynamo machines, each capable of supplying 275 lamps, or a total of 550 lights for the two. This, it is thought, will sufficiently light the whole of the building. But as a necessary precaution, a third dynamo has been provided in the event of any mishap occurring to the two already mentioned; thus dispelling any fear of sudden stoppage in the supply of the light. The company have endeavoured to provide against any sudden emergency that might arise, the gas fittings being still retained in both chambers and in the library; but unless both engines should break down it is presumed there will not be occasion to resort to the use of gas for lighting purposes.

THE EFFECT OF ELECTRICITY ON DUST, SMOKE, AND METALLIC VAPOURS.—A correspondent of the *Journal of Gas Lighting*, writes as follows:—"Descriptions have been given of the effects of high-tension electricity upon dust, smoke, and vapours of various kinds, when confined within glass vessels or other closed chambers. The discovery is due to experiments made by Professor Lodge, of Liverpool, who read a paper on the subject before the members of the British Association at Montreal in 1884. As an illustration, the following remarkable and interesting phenomena are to be noted:—If a glass receiver be filled with smoke of the densest (blackest) kind, and quietly left to itself, some hours will elapse before it will settle. If a current of electricity be passed into the jar, the smoke will begin to whirl about the brass-point conductor, and in a few seconds gather in flakes on the sides and bottom of the vessel. So also with a metallic vapour—say the fumes from lead smelting furnaces. This treated in the same way will quickly form itself into white flakes, not unlike snow-flakes. Electricity! What do we know about it? I began to work at it in 1817; and I am now a learner more anxious for further information than ever before. By the discoveries just now breaking in upon us, may it not be expected that this science—already so high up among the sciences—has many more secrets yet to reveal? Grand and beautiful as some of the exhibitions of electric lighting are, with more yet to be done in this way, may we not believe that here and now we are only looking in over the threshold of a widely-opening doorway, beyond which are stored practical applications of this all-pervading element reaching beyond our thoughts or imaginings? Now comes the question to which all the preceding has been conducting; and it is this: Are there not some gas experts who would turn their hands and thoughts in this direction, and observe the effects of high tension electricity upon coal gas? This should be done in (say) four of the successive stages of its production—(1) Crude gas direct from the hydraulic; (2) after passing through scrubbers, washers, and condensers; (3) at the outlets of the purifiers; and (4) as delivered into the street mains. The experiments would not be difficult or expensive; only special care must be taken that no air be mixed with the gas in the receiver, so as to guard against explosion."

THE ELECTRIC LIGHT IN ART GALLERIES.—A report has been presented to the City Council of Manchester by the Art Gallery Committee with reference to the adoption of the electric light for the Art Gallery. The sub-committee, to whom the subject was referred in November last, we are informed, state that before deciding upon any system they visited the Liverpool Corporation Free Library and Reading Rooms, where the electric light has been in use in several of the rooms for the past five years, with such satisfactory results in regard to the improved temperature of the rooms, better lighting, and other advantages, that they are now extending the system to all the other public rooms in the buildings. The committee recommend that the tender of the Edison Electric Light Company, amounting to the sum of £1,715, be accepted, subject to the approval of the council, and to such terms as to the completion of the works as the committee may decide on. This tender includes the following, viz:—Two 16 h.-p. Otto gas engines, with all the latest improvements and necessary fittings; two compound self-regulating Elwell-Parker dynamos, each capable of delivering a current sufficient for 250 lamps; provision also is made for 385 lamps, with all the necessary wiring up, including foundations for engines and dynamos; the work to be carried out in conformity with their specification and the general memoranda prepared by the city surveyor, dated February 11, 1885, and maintained by them for a period of six months after completion. In considering the question of cost, the sub-committee are of opinion that the increased annual expenditure will not exceed £259. 10s., made up as follows:—4 per cent. on £1,715 for first cost, £68. 10s.; depreciation of engines and dynamos—say £1,300, at 7 per cent.—£91; renewal of lamps, £80; attendance (extra), say £20—total, £259. 10s. The present expenditure for gas lighting amounts to about £100 per annum, and the same amount of gas would still be required for feeding the gas engines. The figures given in this report as to the annual cost show that it would be more expensive to light the building by the electric light than by gas, but when the following considerations are taken into account the sub-committee are strongly impressed with the desirability of adopting this system:—1. Improved lighting of the building. 2. Improved temperature of the rooms, as less heat would be generated, and therefore less necessity for the admission of such a plentiful supply of cold air, which has a tendency to carry with it dust and soot. 3. Additional attractions to visitors, increasing the receipts at the annual exhibitions. 4. The rooms on the ground floor could be better utilised and made more attractive for the permanent exhibition. 5. Additional inducements to artists to send in better pictures. 6. Great saving of damage to pictures, more especially to the permanent collection. 7. Annual saving in the cost of cleaning and painting the rooms. The Art Gallery Committee approve of the sub-committee's report.

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ON THE DESIGN AND CONSTRUCTION OF DYNAMOS.

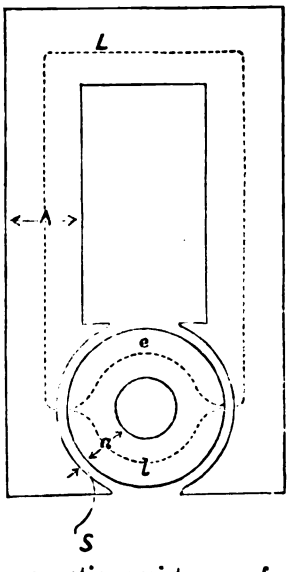
BY GISBERT KAPP.

(Continued from page 191.)

We have seen that the magnetic resistance of the air space is of the character, length divided by area, and it is reasonable to expect that the two other resistances, namely, that of the field magnets and that of the armature, can be similarly expressed. We are not able to prove this on mathematical grounds in the same simple and rigorous manner as was possible when we determined the resistance of the air space between the poles of a perfect magnet, and, indeed, the question of saturation greatly complicates the case; but experiment shows that for low degrees of magnetisation this view of the nature of the resistance of iron is sufficiently accurate for practical purposes, the more so as the resistance of the air space is always considerably greater than that of the iron in field magnets and armature together. Before proceeding with the determination of these resistances it will be necessary to make an assumption as regards the question of saturation. The formula $J = \frac{4\pi P 10^{-1}}{2\delta}$ contains no so-called saturation term, and as it is rigorously correct if δ be very small in comparison to the extent of the polar surfaces—a condition which is fulfilled in most modern dynamos—we shall be justified in assuming that it is impossible to saturate the air space with lines; in other words, that the number of lines passing across the air space in a perfect magnet is always strictly proportional to the exciting power. On the other hand, we know that in our dynamos there is a limit beyond which no amount of exciting power, however large, can produce a sensible increase in the number of lines, and that saturation comes in somewhere in the magnetic circuit. Since it cannot be in the air space it must take place in the iron. This has long been recognised by all who have experimented with electro-magnets, and a number of formulæ have been proposed by which the relation between exciting power and magnetic moment of an electro-magnet can be more or less accurately expressed. These formulæ are all intended for straight bar magnets, spheres, or ellipsoids, and consequently quite useless for the complicated and irregular shapes of dynamo magnets. The only formula which meets the case in some sort of way, though very imperfectly, is that devised by Fröhlich, in which he introduces a so-called saturation term. According to this formula, the strength of field is given by the expression

$$\frac{GP\kappa}{1+\sigma P},$$

κ being the coefficient of magnetic permeability—that is, the power of the core to multiply the magnetic effect of a simple solenoid taken *per se*—whilst σ is the coefficient of saturation, and G a coefficient depending on the shape, size, and arrangement of the field magnets and pole pieces. The latter is now, as before, the stumbling block to a practical application of this formula. It is of no use to know κ and σ if we must also know the coefficient G, which can only be found by experiment after the dynamo is built. What is wanted in practice is a formula by which we can determine, with a fair degree of approximation, the performance of a dynamo before it is actually made. But Fröhlich's formula has also this defect, that it does not take into account the difference which evidently exists with regard to saturation in those parts of the magnetic circuit which lie in iron and those which lie in air. If Fröhlich's formula were correct the characteristic curve of a separately excited dynamo—we take this as an example so as to avoid the complication of critical resistance—would be a continuous curve from the origin to infinity, presenting its concave side to the axis of abscissæ. In reality, however, this is not so. The curve consists in nearly all cases of two portions, one almost a straight line starting from the origin, and the other a curve proper. In some cases it even has an inflexion near the origin presenting its convex side to the axis of abscissæ. A formula to be of practical value must at least in some measure fit these experimental facts, but Fröhlich's formula does not fulfil this condition. In attempting to establish a more serviceable formula it will simplify matters if we neglect saturation at first altogether; in other words, if for the present we only deal with very low degrees of magnetisation. All the magnetic resistances can then be simply expressed as quotients of length and area. Let in the annexed sketch L be the length of that part of the magnetic circuit which lies within the field magnet, and which is indicated by the dotted line; let A be the thickness of the core, the same all round, and B its width. Then if the core be of rectangular



cross-section the magnetic resistance of the field magnet taken from one polar surface to the other will be proportional to $\frac{L}{AB}$. Similarly, if we call a the radial depth and b the length of the armature core, this length being exclusive of any insulation by which the mass of metal may be subdivided into a number of thin discs, the area of iron available for the passage of lines of force will be $2ab$, and their mean length within the armature will be given by the dotted line l. The magnetic resistance of the armature core is therefore proportional to $\frac{l}{2ab}$. The magnetic resistance of the two air spaces has already been found to be proportional to 2δ divided by the surface of the air space. Let λ be the arc embraced by either pole piece; then λb is that surface, and $\frac{2\delta}{\lambda b}$ multiplied with a certain coefficient gives the magnetic resistance of both air spaces. The question is how to find these coefficients for armature, field-magnets, and air. It must be remarked that these coefficients simply depend on the quality of the iron, but have nothing to do with the geometrical form of the machine. In this respect they are not open to the same objection as the coefficient G, which must be determined experimentally for every new form of magnet. Once these coefficients are determined for a certain quality of iron they can be used for all machines made of this iron, no matter what their size, special form, or arrangement may be. The author has found from numerous experiments made with machines of different forms, but all having magnets and armatures of soft wrought iron carefully annealed, that the coefficients are:—2 for the field magnets and the armature, and 1,440 for air. Our formula therefore stands thus,

$$Z = \frac{P}{\frac{2L}{AB} + \frac{2l}{2ab} + \frac{1{,}440 \cdot 2\delta}{\lambda b}}$$

where Z is the total number of lines entering the armature core between two neutral points, and due to the exciting power P on one complete horseshoe of the field magnets, and where the other symbols have the meaning, as explained above. If the field magnets be of cast iron the formula must be modified to

$$Z = \frac{0{\cdot}8\ P}{\frac{3L}{AB} + \frac{2l}{2ab} + \frac{1440.2\delta}{\lambda C}}$$

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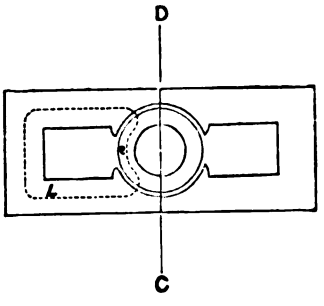
Denoting, as before, by Nt the number of wires counted all round the outside of the armature and by n the number of revolutions per minute, we find the internal electromotive force in volts by the formula

$$Ea = 10^{-6} Z N t n.$$

The expression for Z has been deduced under the supposition that the field magnets consist of only one horseshoe. If there be a double horseshoe magnet as shown in the annexed sketch, the whole machine can be considered as symmetrical to the line C D, and each horseshoe has to supply only half the amature with lines. Calling, again, P the exciting power on one horseshoe and λ half the length of arc in inches



embraced by each pole piece, we have for wrought-iron magnets

$$\frac{Z}{2} = \frac{P}{\frac{2L}{AB} + \frac{2l}{ab} + \frac{1440.2\delta}{\lambda C}}.$$

In this formula, as in the preceding one, all dimensions are to be taken in inches and the exciting power in ampere turns. The lengths L and l should be measured from points about the middle of the polar surfaces so as to represent the average length of lines.

If we divide the number of lines by the area of the core which carries them, we obtain the density, and this must not exceed a certain limit. Otherwise we approach saturation and the above formula for Z cease to be applicable in their present shape. In this case a correction becomes necessary by the introduction of a saturation term which will be given later on. The limit for the density of lines is not very rigidly fixed, as one can easily see from any characteristic curve, which shows that the transition from the straight to the bent part of the curve is very gradual. Neither is it necessary that we should know the limit with any great degree of accuracy, for the working condition of a dynamo is for commercial reasons always considerably beyond it. From actual experiments the author is inclined to consider ten lines per square inch as the density of lines in either armature or magnet cores, up to which no effect due to saturation can be detected. Beyond this density saturation begins and makes itself felt by an apparent increase of magnetic resistance. This increase is seldom less than 25%, but may reach 100% and even higher in machines which contain so little iron that the density of lines becomes abnormally great. Formulæ for determining the apparent increase of magnetic resistance will be given later on; for the present we shall content ourselves to find its amount by a practical example. For this purpose we choose the Edison-Hopkinson dynamo, which has lately been described in *The Engineer*. From the figures there given we find that the armature core is 9·7in. diameter, 18in. long, whilst the magnet core has an area of 171 square inches, and the two exciting coils are each 24in. long. Total number of external wires on armature, 80; speed, 800 revolutions per minute, and external electromotive force 110 volts. Since the loss of electromotive force due to resistance of armature is only about 3 volts, we have

$$Ea = 113 = 10^{-6} Z \,.\, 80 \,.\, 800,$$

and therefore $Z = 1760$.

The air space is about ·55in. wide, and the arc spanned by either pole piece is 12in. We do not know what is the proportion between iron and insulation in the armature, but we may take it that out of the 18in. total length about 1·5in. is occupied by insulation, making $b = 16·5$.

From a sketch of the machine we take $L = 85$, $\lambda = 12$, $l = 12$, and $a = 3·25$. The magnetic resistance is now computed as follows:—

Field magnet	$R_F = \frac{2L}{AB} =$	1·000
Armature	$R_A = \frac{2l}{2ab} =$	·225
Air	$R_a = \frac{1,440 \cdot 2\delta}{\lambda b}$	7·450
	Total	8·675

If there were no such thing as saturation, the exciting power required for this machine would therefore be $8·575 \times Z = 15,200$ ampere turns. In reality we find, however, that the exciting power required, or at least provided, for this machine is 21,300 ampere turns. It is as though the magnetic resistance had been increased by about 40 per cent. In this machine the density of lines is in the armature 16·4 and in the magnet cores 10·3 per square inch. It will hardly be necessary to point out that when speaking of lines we do not mean unit lines in absolute measure, but those representing the arbitrary measure we have adopted in the preceding equations. The relation between our lines and lines in absolute measure is 1 to 6,000; that is to say every one of our lines represents the magnetic effect of 6,000 unit lines, or, in other words, one line of our system will act on unit pole with a force of 6,000 dynes. To prove this we have only to go back to the conception of intensity of field given in a previous article (page 512, Vol, XIV.). Let J be the average intensity of field in the air space taken over half the circumference; let, further, d be the diameter of armature, and let the other symbols stand as before, with the only difference that now centimeters and not inches are meant, then we have

$$Ea\,10^8 = J\,b\,\frac{Nt}{2} \,.\, \pi\, d\, \frac{n}{60}.$$

We write $\frac{Nt}{2}$ because both halves of the armature are coupled parallel, and $\frac{Nt}{2}$ is actually the number of wires within the field of one pole. $\pi d \frac{n}{60}$ is the speed of these wires in centimetres per second. Writing now the equation in the form

$$Ea\,10^8 = J\,b\,\frac{\pi}{2}\,d \,.\, N\,t \,.\, \frac{n}{60}$$

we see that $J\,b\,\frac{\pi}{2}d$ simply represents the total number of lines passing across the semi-circular air space. Call this number ξ, we have $60\ Ea\,10^8 = \xi\, N\, tn$, whilst in our system we have $Ea\,10^6 = Z\,N\,t\,n$. It follows, therefore, that $\xi = 6000\ Z$.

Having now definitely settled the relation between our lines and absolute measure, we will turn to the application of the above formulæ to some practical cases. It will be evident that in all self-excited dynamos the exciting power must depend on the electromotive force—in fact, is proportional to it. On the other hand, the electromotive force exists only by reason of the field magnets being excited, and therefore depends on the exciting power. Unless a given exciting power can produce an electromotive force slightly higher than is absolutely necessary for maintaining that original exciting power, the machine ceases to act. Here we have the principle of the critical speed in dynamos, a term probably first made use of by Marcel Deprez. If the speed is too low, or is gradually diminished until the critical point is reached, the electromotive force is gradually reduced and finally sinks so low that it cannot produce that minimum of exciting power to which it corresponds, and the machine ceases to be magnetic. An example will make this matter clear. Say we have a series wound dynamo supplying a current, c, to a circuit of r ohms. Its own electrical resistance is r_0 ohms, and there shall be T turns of exciting wire on its field magnet, which we assume to be a single horseshoe. The magnetic resistance of the

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dynamo we denote by R. The following equations must now obtain :—

$$Z = \frac{P}{R} \qquad c = \frac{Ea}{r_0 + r}$$

$$P = c\,T \qquad Ea = 10^{-6} Z\,N t\,n.$$

On the critical point exciting power and electromotive force just balance each other without any margin on either side. In this case we have

$$P = \frac{T\,10^{-6}\,Z\,N t\,n}{r_0 + r}$$

and dividing by Z, we find

$$R = 10^{-6}\frac{T\,N t\,n}{r_0 + r}$$

In order that the dynamo may work without the danger of losing its current entirely, its magnetic resistance should be smaller than this value

$$R < 10^{-6}\frac{T\,N t\,n}{r_0 + r}$$

If R be larger the dynamo will not self excite.

(To be continued.)

PRIVATE INSTALLATIONS OF ELECTRIC LIGHTING.*

BY RALPH H. C. NEVILE.

(Concluded from page 236.)

The arrangement mentioned answered very well, and the lights could be varied from 1 to 100 and the boiler pressure from 30lb. to 60lb., with very slight variation of electromotive force in the mains, provided of course there was sufficient steam to do the work required. It is also quite easy to cause the electromotive force to rise as the load on the engine increases—or in other words as more current passes through the main—by simply giving greater leverage to the piston connected with the steam chest. In fact with this arrangement the electromotive force can be maintained practically constant, or can be made to vary in any desired manner with variations of steam pressure or of load.

The main leads to the house having a resistance of about 0·2 ohm, there is a loss of about 12 volts of electromotive force when 60 amperes of current are passing along them between the terminals of the dynamo and the house, whereas when only one or two amperes are passing the loss is practically *nil*. Hence, if the electromotive force were maintained constant in the dynamo room, it would fall at the house as more lights are turned on. In the case of an engine controlled by an isochronous governor this difficulty is supposed to be met by the compound winding of the dynamo machine. There are, however, several disadvantages in that plan. One is that each dynamo ought to be specially wound for the electromotive force desired to be maintained, and for the external resistance between the lighting centre and the dynamo; and if either the electromotive force of lamps used or the external resistance is varied, the adjustment of the machine is destroyed. This also in a great measure prevents the use of reserve machines for a large installation where several circuits are used, because the reserve machines cannot suit all the circuits equally. Another disadvantage in a compound machine is that, if it be used in conjunction with secondary batteries and the engine be permitted to slow down before the connection between the dynamo and the batteries is broken, the current from these last will flow back through the dynamo, and will reverse the polarity of the magnets if it be a compound machine; and when next started the batteries and dynamo will be wrongly connected, and considerable harm may ensue both to batteries and to dynamo.

The plain shunt-wound machine is free from these objections; but the disadvantage has hitherto been that, as more lights were put on, the electromotive force fell just when it should rise. With an electrical governor this can be obviated, as indicated above, by a suitable arrangement of the piston actuated by the steam from the steam-chest. But a still better plan is probably that adopted by the author, of taking certain points as lighting centres, and keeping the electromotive force between them constant. For this purpose small wires are connected with the mains at the required points, and the current to actuate the governor is taken off there, instead of direct from the terminals of the dynamo. One of the points is just outside the house, where the wires enter; and the other point is in a room. The electromotive force between one cable at the first point, and the other cable at the second point, is maintained constant by the governor.

This arrangement could easily be applied to a large installation for a town, each engine and dynamo having its particular district. The cables would be led direct to the district, and governor wires would be led back from the district to the engine governor. The arrangement of splitting up the required power into several small engines, instead of employing only one or two very large engines, permits of this plan; and also requires very much less reserve of power to provide against a break-down. For example, if the lighting of a town be estimated to require 2,000 indicated horse-power, and this be divided between two engines of 1,000 indicated horse-power each, it will be necessary to have either one or two similar large engines in reserve, according as it is intended to provide against a single or double break-down. If, however, the same power be divided amongst forty engines of 50 indicated horse-power each, it will only be necessary to have a reserve of one or two of these smaller engines for providing against similar contingencies. A simple arrangement of switches would then at once permit of a reserve engine with its regulator being switched on to any particular circuit on which it might be required, owing either to a temporary break-down or to a special extra demand for current.

Another advantage of an electrical governor over any arrangement of isochronous governor, however perfect, is that the electrical regulator takes its regulation from the mains, and not from the engine; consequently if there be any loss, either by slip of belt, or by extra heat in the field-magnet circuit or the armature, causing increased resistance, this will be compensated by the electrical governor at once driving the engine so much faster as to make up for it. On one occasion when experimenting with the governor this was specially noticeable; for when the load got rather heavy, the belt at the time being rather too slack, the engine suddenly increased its speed considerably, but the voltmeter remained at the same point, and the dynamo was found to be running at just about its ordinary speed, the extra speed of the engine being evidently caused by slip of belt.

When the lever arrangement was completed several experiments were made by Mr. Richardson and the author, the results of which were as follow. When the load on the engine was allowed to remain constant, with only one lamp alight, it was found that while the steam pressure was allowed to vary between 31lbs. and 55lbs. the electromotive force remained constant at 90 volts. Afterwards, with the same extent of variation in steam pressure, and with the load also varying from 1 lamp to 91 lamps, the electromotive force varied only 2 volts, namely from 91 volts to 93 volts. The following are the particulars of this second set of trials :—

Steam Pressure. lbs.	No. of Lamps.	Electromotive Force. volts.	Steam Pressure. lbs.	No. of Lamps.	Electromotive Force. volts.
55	1	92	45	61	92
55	11	91	35	50	92
55	21	91	32	41	93
55	31	91	32	31	93
55	41	92	32	80	92
55	51	93	30	71	92
55	61	92½	35	91	92
55	71	92	40	91	93
55	81	92	45	91	93
55	91	92	50	91	92½
50	91	92	50	91	92

The arrangement of the governor has since been modified in order to obtain a neater looking arrangement and also better results. Here there is also the advantage that, if an ordinary centrifugal governor be added to the engine—which

* Paper read before the Institution of Mechanical Engineers, at Lincoln, on the 4th inst.

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may be done as a measure of safety, in view of a wire breaking or of the main driving belt coming off; and which must be done if the engine be required to do other work, such as sawing or pumping, at times when the dynamo is not running —the throttle-valve will still be compensated by the lever, which would not be the case if the compensating arrangement were attached only to the solenoid.

As regards the variation in upward pressure on the valve spindle, caused by different pressures in the steam chest and boiler, in one diagram which was taken the maximum difference shown is 6lbs., and in a second it is only 3lbs.; and as the solenoid used has a pull of about 25lbs. with an electromotive force at its terminals of 100 volts, while a variation of 1 volt causes a variation of about 4lbs. in the pull, the maximum difference in the electromotive force ought not to exceed 2 volts in the first diagram, or 1 volt in the second. When the cores of the solenoid are in the most favourable position, the difference of pull caused by a small movement of them is very slight; and the movement required to open or close the valve is very small.

When it is desired to vary the electromotive force in the mains, a set of adjustable resistance coils is inserted in the governor circuit; by increasing these resistances, a higher electromotive force is required to drive the normal current through the solenoid, and thus to close the valve. In this way the speed of the engine and the electromotive force in the main wires may be varied to almost any required extent, and from a point however distant from the engine. The author has one set of these coils fixed in the circuit in the dynamo room, and another at a certain point in the house, and by moving either of these the resistance may be increased or diminished, producing a corresponding variation in the electromotive force. This is found a great convenience when exceedingly exact electromotive forces are required for experimental work, which sometimes cannot be carried on in the immediate neighbourhood of the dynamo machine. It may also be arranged practically to dispense with the necessity of any telegraph or signal to the engine room, because a switch and set of coils placed in any convenient position afford the means of varying the light as desired, without any reference to the engine driver, whose work then consists simply in seeing that steam and water are maintained in the boiler, and the bearings kept oiled.

In the case also of an engine doing any other work, where it is desired to vary its speed from a distance, the same governing arrangement may be applied by causing the engine to drive a small dynamo just sufficient to furnish electricity for the electrical regulator. The electromotive force in the mains would then furnish at any desired point an indication of the speed of the engine at any moment; and a switch and set of resistance coils would afford the means of altering the speed to any other desired rate. As the amount of current required for driving the regulator is only small, the coils and switch may be made very small and compact, so that in a theatre, for example, they might be placed in the prompter's box, and the whole system would then be under his immediate control.

The introduction of this governor has in the author's opinion contributed very largely to the duration of the lamps used. From the first start until the end of last year the time of running was 370 hours, and during that time with the old governor five lamps gave out, although they were all new when the installation was started; the average current during that time was 16 amperes. Up to 13th January last, when the new governor was first introduced, the time of running was 477 hours, and thirteen lamps had given out; probably also many of the others had been damaged. Nevertheless, during the 487 hours' running in February, March, and April, although the average current used had increased owing to the extension of the installation, only ten lamps gave out; and during the 84 hours' running in June only two lamps gave out. Hence it appears that a good governor will soon save its own cost by an increased life for the lamps.

Thus far reference has been made solely to incandescent lighting in parallel; but for arc lighting in series the advantages of a governor of this description are very conspicuous. Probably the best system of driving arc lights in series is by the use of a series-wound dynamo, especially if a compound engine be used for the purpose, because then the steam-chest pressure remains approximately constant, and the speed varies approximately in accordance with the number of lamps in use. Here an isochronous governor is obviously altogether useless. An electrical governor, however, meets the case perfectly. Here the whole of the current to the lamps is led round the solenoids, which are of course made with fewer coils of a thicker wire. When any lamps are short-circuited, a momentary increase of current takes places, which instantly raises the cores in the solenoids, and shuts off the steam, reducing the engine to the required speed for the number of lamps left on. The following are particulars of some experiments made in 1883 by Prof. Thompson, of University College, Bristol, with a machine of this description:—

Lamps alight.	Amperes of current.
0	10·6 — 11·2
5	10·0 — 10·5
11	10·0 — 10·3
16	9·9 — 10·2
17	10·1 — 10·2

Before the introduction of this regulator very considerable trouble was experienced in keeping the speed at the proper point, and many of the fine-wire coils of the Brush lamps were destroyed by an excess of current going through the circuit. Now, however, the current has been effectually controlled, and any number of lamps can be switched in or out without any attention being paid to the engine. An arrangement has also been introduced by which, should the main lead become accidentally severed, the engine is at once stopped. A small electro-magnet is introduced, round which the current is led with a few turns of wire. The magnet supports a weight of several pounds, which is attached to a lever so pivoted that, when on the cessation of the current the weight falls, the lever presses with great force on the the top of the valve-spindle, and shuts off the steam altogether.

A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Allow me to point out an error in your notice of Mr. Richardson's governor on page 227 with reference to compound engines. It is not claimed for this governor that with it a compound engine will develop 5 horse-power with the same economy as 50 horse-power *at the same number of revolutions per minute*, but that when using a series machine for arc lighting it will reduce the number of revolutions per minute very nearly in proportion to the horse-power developed, and *thereby* produce an equally economical result whether developing 5 or 50 horse-power. For example, in the case of the installation at Messrs. Robey's works referred to at the end of my paper on "Private Electric Lighting," the machine used is a Brush machine. To keep up the proper current the engine driving this machine makes 150 revolutions per minute when all seventeen lamps are alight, but when they are reduced the speed of the engine falls in almost the same ratio, until when they are all short circuited the engine makes only fourteen revolutions, just causing enough E.M.F. to drive the current through the field magnet coils and the electrical regulator. It must be evident that this arrangement causes very much greater economy than continuing to drive the engine at full speed, with perhaps only one-tenth of its full load on, and diminishing the power of the dynamo by any such device as shifting the position of the brushes or shunting a portion of the current past the field magnet coils. Moreover, the electrical regulator performs this office, instantaneously reducing the speed as soon as the moving parts can lose their momentum after any lamp or lamps are short circuited, and automatically, thereby requiring no attention or signal to the engine driver when it is intended to extinguish any lamp or group of lamps.

—Yours, &c., R. H. C. NEVILE.

Wellingore Hall, Grantham, August 11, 1885.

P.S.—The economy is evident even when using an ordinary high pressure engine, but is most noticeable with a compound engine, to which Mr. Richardson's paper was especially referring.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE INTERNATIONAL TELEGRAPH CONFERENCE.

We have had recently to animadvert on the danger to cable property resulting from the undue political influence of a particular State; we have now to protest against interference which may prove even more dangerous, due to the combination of a number of States, hardly any of whom possess cables of their own, and none to be compared with the possessions of private companies. The officious interference of France, and the servility with which her leading has been followed in the matter of "protecting" submarine cables were bad enough; but the manner in which the international confederacy, now sitting at Berlin, proposes to deal with their revenues is something even worse. Just as at Paris, the great cable proprietors have no voice in the decisions to be arrived at, or if they have a voice at Berlin they have no vote. This, however, is perhaps not to be regretted, for the representatives of the fourteen submarine companies who are unofficially present at the Conference might be easily outvoted; and for the purposes of an effectual protest a non-voting position is stronger than one that has been beaten on a fair division.

With the Conference's proposals relating to a uniform international inland tariff we need not concern ourselves very much. The fundamental charge (*grundtaxe*) of fifty centimes, and twenty centimes per word, are far too low for States of great territorial magnitude, and we are not surprised that Russia, for one, objects to this proposition. The transit tax—that is the claim which one State through which a message passes will have upon the forwarding and receiving States—is extremely small, though an attempt is here made to graduate it according to the size of the transmitting intermediary. Great Britain, though counted among the larger countries, will claim only four centimes—less than a halfpenny—per word for messages travelling, say, between the continents of Europe and America, and passing over her land lines; a claim which will not assist her in recovering the probable loss on sixpenny telegrams locally. But the respective countries concerned may be safely left to fight their own battles with the weapons they are privileged to use. The Cable Companies have their independent position to defend, and this with no instrument except that which free speech in a just cause affords them. They have not had much for which to thank these Telegraph Conferences in times past; but hitherto they have submitted with a good grace. On the present occasion, if the propositions which fell through at the last gathering, and which are revived in the present, should be carried, cable owners will have to reconsider their position with regard to the Union, for there will be then, it seems to us, no choice between disloyalty on the one hand or ruin on the other.

Dr. von Stephan's proposition has only to be stated to make this clear to most of our readers. He recognises that the uniform international rates above described will require to be increased where a message traverses a submarine cable; but the extent to which he thinks it right to modify the uniformity is at most by the magnificent sum of ten centimes per word; for distances under 300 nautical miles by only five centimes per word. Now, a vast number of messages travelling over submarine cables are transit messages—that is to say, messages not originating at the offices of the companies; consequently, for all this traffic the cable companies would be paid often at only a halfpenny per word, never more than at a penny. Even if such rates were possible of acceptance for this portion of the business, it is obvious that the higher rates on messages originating with the companies could not long be maintained; and it is equally obvious that the addition of fivepence *grundtaxe* would not enable them to do the business and live. Of the present European Submarine Cable rates the lowest is sixpence per word, ranging from this to one shilling and eightpence per word. The cables most affected are not in a flourishing condition even with these rates; and if Germany is to have her way in this matter they may as well close their offices at once. All the other companies would be more or less injuriously affected, some to the tune of fifty or sixty thousand pounds per annum. Not one of them would at this moment voluntarily reduce its rates in any material degree, nor to a uniform rate of any kind; and certainly not to one as low as the present lowest rate, which is a vast deal higher than that which Dr. von Stephan proposes to confer upon them.

Of course there is the usual talk about the increase of traffic consequent upon reduced charges. This may be or may not be true of inland telegraph traffic; but there is no probability of ever creating a popular tariff for submarine cabling, and assuredly no present possibility of forcing it. Popular tariffs are for local traffic, or for countries closely adjoining. The principles which hold good for them cannot be applied to countries wide apart, especially if separated by the watery barrier which submarine cables bridge over but do not annihilate. We are warned by the inspired Berlin correspondents of the London newspapers against a short-sighted and insular policy. Dr. Stephan is held up to us as a sort of German Rowland Hill, and in one quarter we are invited to believe that the main object of his proposal is to "add a new bond to international relations in the interest of peace." That may be a consequence, but it can hardly be the object; or, at all events, if such it be, it is pursued with flagrant disregard for the welfare

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or peace of the community to whom more than to any other we owe the bonds of modern international relationship. Legislating for themselves the States represented at Berlin have a right to sacrifice their pecuniary interests for the sake of peace or anything else they may fancy; but they cannot expect private capitalists to do more than sympathise with these lofty motives. If more is demanded in the interests of European amity, then the European States ought to purchase their right to legislate, and stand by the loss. It is impossible to suppose that the Conference will be able to convince itself of the financial advantages of a five or ten centimes word rate for cablegrams; and this being so there is not the smallest justification for asking cable proprietors to perform the happy despatch in order that the reputation of Dr. Stephan or the interests of the European commonwealth may flourish and be glad. In the course of their career the Cable Companies of Great Britain have afforded many and conspicuous proofs of their patriotism, public spirit, and unselfishness. But as they do not enjoy the advantages of governmental administrations, who can fall back upon general taxation to make good their deficits, their generosity is necessarily limited by their unaided resources; and these at present are not over ample.

ON THE USE OF DANIELL'S CELL AS A STANDARD OF ELECTROMOTIVE FORCE.*

BY J. A. FLEMING, M.A., D.SC. (LOND.).

(*Concluded from page 233.*)

A large U-tube, about ¾-inch diameter and 8 inches long in the limb, has four side tubes (Fig. 2). The two top ones,

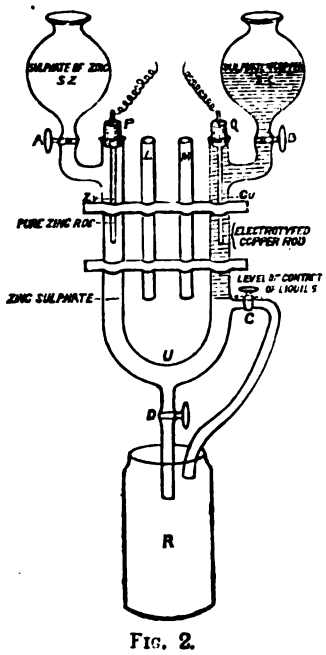

FIG. 2.

A and B, lead to two reservoirs, Z and C, and the bottom ones, C and D, are drainage tubes. These side tubes are closed by glass taps. The whole is mounted on a vertical board, with a pair of test-tubes between the limbs. Suppose, now, a Daniell's cell is to be formed with solutions of zinc sulphate and copper sulphate, and that the zinc sulphate solution is the denser. The left-hand reservoir S Z is filled with the zinc solution, and the right-hand reservoir S C with the copper solution. The electrodes are zinc and copper rods, Zn and Cu, passed through vulcanised rubber corks, P and Q, fitting air-tight into the ends of the U-tube.

The operation of filling is as follows:—Open the tap A and fill the whole U-tube with the denser zinc sulphate solution; then insert the zinc rod and fit it tightly by the rubber cork P. Now, on opening the tap C the level of the liquid will begin to fall in the right-hand limb but be retained in the closed one. As the level commences to sink in the right-hand limb, by opening the tap B copper sulphate solution can be allowed to flow in gently to replace it; and this operation can be so conducted that the level of demarcation of the two liquids remains quite sharp, and gradually sinks to the level of the tap C. When this is the case, all taps are closed and the copper rod inserted in the right-hand limb.

Now it is impossible to stop diffusion from gradually mixing the liquids at the surface of contact; but whenever the surface of contact ceases to be sharply defined, the mixed liquid at the level of the tap C can be drawn off, and fresh solutions supplied from the reservoirs above.

In this way it is possible to maintain the solution pure and unmixed round the two electrodes with very little trouble; and the electrodes, when not in use, can be kept in the idle cells or test tubes L and M, each in its own solution. In making experiments concerning temperature, the whole U-tube can be immersed in a vessel of water or ice up to nearly the top of the reservoirs, and the temperature in the solutions taken by means of a thermometer passing through the rubber cork. Each of the electrodes can be removed for examination or change without in the least disturbing the surface of contact of the solutions. If experiments are being made in which the sulphate of copper solution is the denser, the position of the solutions is interchanged. The bottle R serves to collect the waste solutions.

The electrodes are made of rods of the purest zinc and copper, about 4 inches long and ¼-inch diameter. The zinc found most suitable is made from zinc twice distilled and cast into rods; the copper prepared by electro-depositing on a very fine copper wire, until a cylinder of the required thickness is obtained.

With these appliances to hand, all the facts recorded by previous experimenters have been carefully repeated and confirmed, and the influence of each variable upon the electromotive force examined. The results are collected as follows:—For the sake of brevity, a Daniell's cell in which zinc, sulphate of zinc, sulphate of copper, and copper are the elements will be called a normal Daniell; and the statements here below refer to the variations in the difference of potential between the poles of the normal Daniell, when sending either no current or only an infinitesimal one, caused by variations in the physical state of the four elements. In each set of experiments the greatest care was taken to keep all the elements constant, except the one which was purposely being varied in order to detect the influence of it on the whole electromotive force.

1. *The Effect of Variation in the Copper Surface and Condition.*

In these experiments the copper- and zinc-sulphate solutions were sometimes of the same specific gravity, sometimes different; and in some cases the zinc electrode was a rod of the purest cast zinc amalgamated with pure mercury, sometimes a rod of commercial zinc wire cleaned but not amalgamated. Some scores of observations were made with identical zinc plate and solutions, but various kinds of copper plates*; and all observations have confirmed the conclusions of Dr. Alder Wright that the most uniform results are obtained from copper plates freshly electrotyped over with a new clean pinkish surface of virgin copper, when the plate is taken

* From the *Phil. Mag.* for August (communicated by the Physical Society. Read June 27, 1885).

* All the following values are given in real volts, taking Lord Rayleigh's value for the mean B.A. unit of resistance as equal to ·9867 earth-quadrant per second.

The determinations have been made against a Clark cell, kindly compared by Lord Rayleigh with his No. 1 cell, whose value is given in his paper in the *Phil. Trans*, part ii. (1884) as 1·435 true volt at 150° C. My standard, called hereafter F_{20}, is greater than this by 3 parts in 4,940, or is 1·436 volt at 15° C.; and experiments have shown that its variation-coefficient is nearly that found by Lord Rayleigh, viz., ·082 per cent. per degree diminution of E.M.F.

Accordingly, the value of this standard Clark cell F_{20} has been taken as equal to

$$1{\cdot}436(1 - {\cdot}00082\,t^{\circ}) \text{ volt at } t^{\circ}\text{ C.},$$

and all values given in the text are in terms of this.

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straight out of the electrotyping bath and put into the cell without any delay or touching except a slight rinse with distilled water. The result of comparing a freshly electrotyped rod with a rod scraped and glass-papered, was to show that the scraped copper rod gave a higher electromotive force by about four parts in 629, or six parts in 1,000. When both rods were freshly electrotyped in the same bath, and inserted in the same cell, there was absolutely no difference between them. Cells were compared with solutions of equal density 1·2 at 15° C. and amalgamated pure cast zinc, but different copper rods, as follows:—

	E.M.F.
Electrotyped copper rod	1·105 volt.
Scraped copper rod	1·111 „

The exact amount of difference varied slightly in other experiments; but with equally clean surfaces, the electrotyped fresh surface has a lower electromotive force than the scraped. The effect of amalgamating the copper rod is, like electrotyping, to lower its value below that of the clean scraped, but it is not so uniform. The following are values obtained from equal copper rods in the same cell, one having an electro-plated surface and the other being slightly amalgamated with pure mercury:—

Freshly Electro-deposited Copper Rod	Freshly Amalgamated Copper Rod.
1·103	1·104
1·106	1·104
1·105	1·104
1·106	1·105

The mean of the values of the electro-deposited copper exceeds by about 1 in 1,000 the mean of the amalgamated copper; but if the amalgamation is done thickly it causes more serious deviations, and though more convenient is not quite so reliable as electroplating the rod with fresh copper, but is preferable to employing simply a scraped or glass-papered surface of rolled copper. A large series of determinations were next made on the effect of oxidation of the copper surface. If a copper rod, newly electroplated, is left in the copper-sulphate solution, it gradually gets oxidised and covered with brown patches of oxide, and if amalgamated, the mercury sinks in and the surface gets brown and patchy. When this is the case the electromotive force rises, and by uncertain amounts, depending on the degree of oxidation. It is very remarkable how small a trace of brownish oxidation on the surface raises the electromotive force several parts in 1,000 amounting in some cases to nearly one per cent. The following is one set out of many experiments on this point:—

Two solutions of zinc and copper sulphate were prepared of the pure crystals. The specific gravity of the zinc sulphate was 1·4, and that of the copper sulphate was 1·1. A rod of pure unamalgamated zinc and one of electrotyped copper was also taken. Keeping all other conditions constant, the rod of copper was first cleanly and carefully electrotyped over with a new fresh surface of copper, and exhibited no trace of oxidation; and the E.M.F. of this cell was then taken against a carefully tested standard Clark cell of known value; and the rod was then suffered to oxidise on the surface by successive exposure to the air, the E.M.F. of the cell being taken at each stage.

	E.M.F. of Cell.
Copper, perfectly pure, unoxidised	1·072 volt.
„ slightly oxidised, brown spots	1·076 „
„ more oxidised	1·082 „
„ covered with dark brown oxide film	1·089 „
„ cleaned, replated with fresh pinkish electro surface	1·072 „

Many other experiments of this sort showed the same thing. A Raoult cell was formed by taking two beakers, one containing zinc sulphate of specific gravity 1·2, and the other copper sulphate of the same specific gravity, and using amalgamated cast zinc and electro-deposited copper rods. The beakers were connected, when required, by a piece of clean cotton-wick dipped in water, and connecting both solutions by dipping into each. The copper pole was first freshly electroplated, and the following values obtained for the E.M.F. of the cell as it gradually oxidized:—

	E.M.F. of cell.
Freshly electro-deposited surface of copper	1·105 volt.
Slightly oxidised, faint brown tinge	1·106 „
More oxidised	1·107 „
Still more oxidised	1·109 „
Re-electroplated surface	1·105 „

Hence these and many similar experiments all teach that oxidisation, even the slightest trace, of the copper raises the E.M.F.; and that, in order to get the real value proper to the combination, the copper must be electrotyped over with a thin pure film of copper, and exhibit no trace of brown spots of oxide, and be used at once.

2. *The Effect of Variation in the Zinc Surface and Condition.*

Numerous experiments have been made to investigate whether there is any certain difference between zinc amalgamated or unamalgamated or cast or rolled. There is very little, if any, certain difference between perfectly pure cast zinc unamalgamated and the same amalgamated with pure mercury. There are greater differences if the zinc is not pure, and variations are introduced if impure mercury is used for amalgamation, all of them uncertain in amount.

The effect of oxidation of the zinc is to lower the electromotive force. If the bright surface of the zinc becomes tarnished, it always shows a slightly lower E.M.F. The smallest deposit of copper upon the zinc, due to diffusion of the copper salt into the zinc, is indicated by a marked depression, amounting to 2 or 3 per cent. On the whole, the only consistent values are obtained from chemically pure zinc with a bright fresh untarnished surface, whether amalgamated or not; and the best results are given with pure zinc amalgamated with pure mercury. In Dr. Alder Wright's memoir the above conclusions are enforced by tabulated results of most extensive experiments.

On the question of amalgamation of the zinc we may quote a note on the subject by M. G. Lippmann in the *Journal de Physique*. There is an opinion expressed by some authors that amalgamated zinc has a higher E.M.F. than unamalgamated, even if pure. If a plate of each of the two substances be immersed in sulphate-of-zinc solution, a couple is formed in which amalgamated zinc forms the negative pole, inasmuch as it is the more readily acted upon by oxygen. Such, at least, is the result obtained if ordinary commercial zinc is used and ordinary sulphate-of-zinc solution. In a recent work, M. W. Robb shows that if care be taken to use electro-deposited zinc, and also zinc sulphate solutions deprived of free acid, the element zinc, zinc sulphate, and amalgamated zinc will not manifest any appreciable E.M.F. The superiority of amalgamated zinc over ordinary zinc is easily explained; but when pure zinc is used, deprived of any oxide on the surface by slight rinsing in dilute sulphuric acid before placing it in the sulphate of zinc, there is little or no certain difference, to the extent of one part in 1,000 in the case of the normal Daniell, between the pure zinc amalgamated or unamalgamated.

3. *The Influence of Density of the Solutions on the Electromotive Force.*

The chief reason for the differences in the values assigned by various observers to the E.M.F. of the normal Daniell is due to the great influence that the specific gravity of the two exciting solutions exerts on the resultant E.M.F. of the combination; and the general law of the effect is this. If a Daniell cell be formed of amalgamated pure zinc, freshly electrotyped copper, and solutions of pure zinc sulphate and copper sulphate of equal specific gravity, then, taking this cell as a standard of reference, increasing the density of the zinc sulphate lowers the electromotive force, and increasing the density of the copper sulphate raises the electromotive force, within, at any rate, the limits of density from 1·01 as an inferior, up to saturation as a superior limit. Zinc sulphate saturated at 15° C. has a density of a little above 1·4, and copper sulphate similarly saturated 1·2; and Dr. Alder Wright shows by experiments that the increment and decrement of E.M.F. for identical increment or decrement of density of

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both solutions are so nearly equal that for equally dense solutions, within limits, the E.M.F. is independent of the absolute density of both. This fact has been confirmed by many other observers. Amongst other careful experiments may be noticed those of Carhart*, whose experiments were specially directed towards ascertaining the influence which variation in the density of the zinc sulphate exerts on the resultant E.M.F.

In using a Daniell cell as a laboratory standard it is necessary, therefore, to prepare and standardise the solutions of zinc and copper sulphates with the same care as if they were to be used for volumetric analysis. It is a good plan to prepare two large stock bottles of solutions, and having carefully determined the density to adjust them to known specific gravity by the aid of the specific gravity bottle or hydrometer. For general use two standard solutions of each salt are specially useful. First, a solution of sulphate of copper very nearly saturated at 15° C. and having a specific gravity of 1·200, and a solution of sulphate of zinc of equal density. Secondly, a solution of sulphate of copper of density 1·100 at 15°, and a solution of sulphate of zinc of 1·4. These last values are chosen because they were employed by Sir W. Thomson in his standard gravity cell; and they can be used in either his form of gravity cell, or in the U-tube form above, or in Raoult's form of separate vessels and siphon.†

A very large number of comparisons have been made of the E.M.F. of cells set up with these solutions and the E.M.F. of Clark's cells, whose value has been compared directly with cells standardised in absolute measure.

If a Daniell cell is carefully made up, either in the Raoult form or U-tube form, of solutions of pure zinc and copper sulphate not sensibly interdiffused at the level of contact, and with pure amalgamated cast zinc and freshly electrotyped copper plate, which is evenly plated with a new uniform pinkish deposit of electro-copper free from all brown spots of oxide, the E.M.F. of this cell, taken at once, is very close to 1·102 true volt, and the ratio of the E.M.F. of this cell to a corrected Clark cell at 15° C. is very nearly ·768 to unity;‡ the Clark cell being taken as 1·435 at 15° C.

If, instead of taking the equidense solutions, we take zinc sulphate of specific gravity 1·400 and copper sulphate of 1·100 at 15° C., and the same plates, the E.M.F. of the cell lies close to 1·072 volt, and the ratio of the E.M.F. to that of the corrected Clark is ·747.

If, however, instead of taking the electromotive force at once after the freshly electroplated copper pole is introduced into the cell, the cell is allowed to stand an hour or so, both the above values will be increased by about ·003 volt, provided always that no interdiffusion of solutions has taken place, and that the zinc retains a perfectly bright untarnished surface.

4. *Influence of Temperature on the Electromotive Force of the Normal Daniell Cell.*

The researches of experimenters who have studied the Clark cell have established the fact that its E.M.F. diminishes with rise of temperature. The exact value of the coefficient of variation seems to depend on the mode in which the cell is made up; and very careful examination has been made of the Daniell cell as above described, to see if its real E.M.F. is affected by temperature. Some writers have asserted that it is; but it is obvious that the variation of internal resistance must be eliminated entirely by the use of a null method of observation of the E.M.F. The condenser method is not a sufficiently accurate one to apply, and the potentiometer method is the most trustworthy.

Two U-tube cells were prepared with 1·4 sp. gr. zinc sulphate and 1·1 sp. gr. copper sulphate; and these cells were respectively immersed, the one in a water bath at 20° C, and the other in melting ice at 0°. A pair of zinc and copper poles was likewise prepared; and when the solutions in the U-tubes had acquired the temperature of the baths, the E.M.F. of each cell was taken with the pair of zinc and copper plates, first in one and then in the other, with the following results:—

Plates in the warm cell at 20° C. E.M.F. of cell.	Plates in the cold cell at 0° C. E.M.F. of cell.
1·081	1·082
1·079	1·082
1·079	1·082
1·078	1·083

The experiments showed a very small but decided fall of E.M.F. as the cell is warmed, and at the rate of about three parts in 1,000 for 20° C. This is only about $\frac{1}{50}$ of the variation of a Clark cell for the same range; and, practically, we may say that the E.M.F. of a Daniell cell is independent of temperature for such range as occurs in the natural temperature of the air in our climate.* This quality of the normal Daniell is very important, and goes very far towards helping it to sustain its position as a standard cell against its rival the Clark cell.

The various coefficients of temperature-change which have been found for Clark cells indicate that it is unsafe to rely upon any cell taken at random, whose history is unknown, having a coefficient of variation accurately the same as that of the cells whose coefficients have been actually determined.

It would be a great advantage if instrument makers would construct these cells in the form suggested by Lord Rayleigh—enclosed in a test-tube and having gutta percha covered leading-in wires passing through a rubber stopper. The coefficients of variation would then be easily obtained for any cell, just as those of standard resistance-coils are ascertained and marked on each cell with the range of temperature over which it is applicable.

As a check on the foregoing experiments on the Daniell, the coefficient of variation of the standard Clark cell used was obtained. Two cells were taken, exactly equal at 18° C., and one of them was immersed for 48 hours in melting ice. The difference on the potentiometer wire was then obtained between this cold cell and its fellow kept in water at 18° C. The potentiometer-readings were as follow:—

	i.	ii.	iii.
B, cell at 0° C.....	961 ...	971 ...	974·4
A, cell at 18° C.	947 ...	957 ...	960
	14	14	14·4

From the experiment 1 the reading for the warm cell would have been $947 + \frac{14}{6} = 949\frac{1}{3}$ at 15°. And hence the coefficient of variation is $\frac{14}{18}$ in $949\frac{1}{3}$, or ·0819 per cent. in the neighbourhood of 15° C. Lord Rayleigh gives ·082 as the value for his cells. It is obvious that Clark's cells cannot be used for standardising galvanometers without a careful determination of their coefficients of variation.

The normal Daniell cell has a certain advantage in that when null methods for determining electromotive force are employed, its value is independent of temperature throughout a considerable range.

By the employment of the above two instruments—a potentiometer as described and a standard normal Daniell carefully constructed with all the precautions named—it is very easy to make very accurate measurements of strengths of currents of large magnitude. If a resistance is formed of such character

* A paper read before the American Association for the Advancement of Science, Sept. 5, 1884. *See Telegraphic Journal and Electrical Review*, Vol. XV., p. 250.

† If 28·25 parts by weight of pure crytallised sulphate of copper ($CuSO_4$, $5OH_2$) are dissolved in 71·75 parts by weight of distilled water, the resulting solution will have very nearly a specific gravity of 1·200 at 18° C.; and if 16·5 parts of the crystals are dissolved in 83·5 parts of water, the solution will have a density of 1·100 at 15° C.

For the zinc-sulphate solutions take 55·5 parts by weight of crystallised zinc sulphate ($ZnSO_4$, $7OH_2$) and dissolve in 44·5 parts of distilled water. The resulting solution will have at 20°·5 C. a specific gravity of 1·400.

If 32 parts by weight of the crystals are dissolved in 68 of water at the same temperature, the solution will have a density of 1·200. These are useful densities.

‡ Lord Rayleigh assigns a value very close to ·770 for this ratio, and Dr. Alder Wright ·765. The figure in the text is derived from about 50 experiments of my own.

* The same result has been obtained by Mr. Preece in his experiments on the effects of temperature on the electromotive force and resistance of batteries, see *Electrician*, March 3, 1883, Vol. X., page 367. He gives a table, showing the E.M.F. at various temperatures, obtained by the condenser method, and shows that there is no perceptible change in E.M.F. of a normal Daniell between 0° and 17°, and a slight fall subsequently of about nine parts in 1,000 between 17° and 28°, but a rise, however, after reaching 63°.

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that the current to be measured can be passed through it without much affecting its temperature and the potential measured at the extremities of this resistance by means of a comparison on the potentiometer between it and that of the Daniell, this gives at once the current.

In order to construct a resistance whose value at the instant of passing the current can be accurately measured, the following device is adopted:—On a board are mounted a series of copper blocks, *a*, *a*, *b*, *b*, like the connection pieces on a resistance-box (Fig. 3). These can be connected by plugs *p*, *p*. At opposite sides and ends are main terminals as M′; and the blocks *a*, *b* are connected by brass or German silver wires wound in a spiral; similar coils of equal resistance

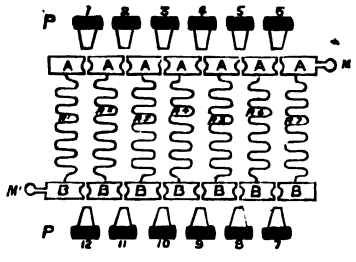

FIG. 3.

connect each pair of opposite blocks. The number of coils must be an odd number.

If the plugs 1, 11, 3, 9, 5, 7 are put in, it is obvious all the coils $R_1, R_2 \ldots R_7$ are a series, and their resistance can be measured; call it *r*. If, then, the other pegs are inserted, the coils are now in multiple arc or parallel, and if there are *n* coils the resistance is $\frac{r}{n^2}$. By this arrangement the resistance in parallel can be inferred from the resistance in series; and although each coil has a very small resistance, yet by using a large number, not only is a very easily measureable resistance obtained when the coils are in series, but a resistance of large current-carrying capacity when they are put in parallel.

The mode of using it is as follows:—The pegs are all put in, and the current to be measured is sent through the coils in parallel. By means of the potentiometer and standard cell the difference of potential is found between the terminals M and M′ when the current is passing. The alternate pegs are then removed, the current stopped, and the resistance taken of the coils in series, and the time noted which has elapsed between the measurement of potential and of the resistance. A few observations are taken of the resistance at intervals of time, by which to construct a curve of cooling; and by projecting back the curve, it is easy to ascertain very nearly the resistance at the time when the potential was measured. If small currents only are employed, it is not necessary to change the resistance; the current can be sent through it in series, and its resistance also measured in series. The writer has had constructed a large resistance of this kind at the Victoria Electric Lighting Station, for the measurement of dynamo currents up to 500 amperes. In this case the resistance consists of 36 wires of brass, No. 14 B.W.G., arranged in parallel and of equal resistance. One of the wires can be disconnected and arranged instantly on a bridge to measure its resistance; and in this way, after measuring the potential at the ends of the 36 wires in parallel, with the current passing through them, one wire is disconnected, and its resistance taken immediately, from which observations it is possible to approximate very accurately to the resistance of the whole wires in parallel. In order to afford data for constructing such resistances, experiments were made of passing various currents through coiled spirals of naked wires of different sizes and materials.

A large number of wires were prepared of copper, brass, iron, German silver, each 25ft. long, and of six sizes respectively, Nos. 10, 12, 14, 16, 18, 20, B.W.G., the diameters being given below. These wires were coiled into spirals round wooden rods about 1in. diameter, and the turns of the wire well separated, so that each coil or spiral was about 18in. long. Measured steady currents were sent through these for some hours, and so adjusted that after the temperature had become steady the wires were all at a temperature just about bearable by the hand, that is near 60° C. The currents respectively carried were as follows:—

Size of wire	No. 10 B.W.G. ·134in. diam.	12 ·109	14 ·083	16 ·065	18 ·049	20 ·035
Currents carried in amperes.						
German Silver	18·75	13·5	8·25	6	4·12	3
Brass	30	18·75	15	9·75	7·5	5·25
Iron	18	11·25	10·5	8·25	5·25	3·75
Copper.....	49·5	38	26·25	20·25	15	9

These currents passed through the above-described naked spirals bring the respective wires to about a temperature of 60° C., when equilibrium is established; and for the purposes of measuring currents not more than one-third of the above currents should be used with wires of the size appended. Thus for 300 amperes, about 50 No. 10 B.W.G. wires will carry it without much sensible elevation of temperature; and by arranging 50 wires so that their resistance can be quickly measured in series, a resistance can be made suitable for measuring the potential at the ends of a known resistance.

By the use of this method it is easy to standardise any current or potential galvanometer at any part of the scale, and obtain the absolute or corrected value of the deflections; and these methods have been employed with success for some time in standardising the working galvanometers used in the lamp factory of the Edison and Swan United Electric Light Company.

In conclusion may be given other results, collected from various authors, respecting the electromotive force of the Daniell cell.

Wiedemann (*Galvanismus*, vol. i. cap. iv., *Bestimmung der Electromotorischen Kraft*, p. 341) gives a description of Raoult's cell (see Raoult, *Ann. de Chim. et Phys.* [4] t. ii. p. 345, 1864), and states that Raoult finds that copper foil has higher electromotive force than electro-deposited copper by about $\frac{1}{200}$; and attributes it to the oxides of copper contained in it. He also confirms the invariability of E.M.F. with temperature at least between 10° and 50°; and states that with pure amalgamated zinc and electro-deposited copper, solution of saturated sulphate of copper and solution of sulphate of zinc, containing one part of crystals to one part of water = 1·35 sp. gr. at 20°, the electromotive force is 1·124 electromagnetic units. This, corrected by the Cambridge value of the B.A. unit, is 1·109 volt.

Sir W. Thomson (p. 245 of "Papers on Electricity and Magnetism") finds the electrostatic measurements of a Daniell's cell to be ·00374. The nature of the solutions and electrodes are not given. Taking the value of *v.* as 3×10^{10}, we have the E.M.F. as 1·12 B.A. volt, which, reduced to true volts, gives 1·105 volt.

Lord Rayleigh gives the ratio of a Daniell set up with amalgamated pure zinc, electro-deposited copper, and solutions of sulphate of zinc and copper, each of sp. gr. 1·1. Five observations of the ratio of this cell to that of a known Latimer-Clark cell at 16° C., taken as unity, gave ·7702, ·7710, ·7705, ·7698, ·7702, mean ·7703; and since the Clark is 1·435 volt, this gives the Daniell as 1·105 volt.

Latimer Clark (*Journal* Society Telegraph-Engineers, January, 1873) gives it as 1·11, which, reduced to true volts, is 1·095; and Dr. Alder Wright (*Proceedings* Physical Society, London, Vol. VI., p. 292) gives the value of a normal Daniell set up with solutions of the same molecular strength, preferably of strength *m* M SO_4 100 OH_2, when *m* is near 2—that is with copper sulphate nearly saturated, and zinc sulphate of equivalent molecular strength, and pure amalgamated zinc plates and electro-deposited copper—as 1·114 B.A. unit, or 1·099 true volt.

None of these are very far from the value assigned to the standard cell described above, viz., 1·102 volt. with equidense solutions and metals as described.

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LITERATURE.

Under the Rays of the Aurora-Borealis in the Land of the Lapps and Kvœns. By SOPHUS TROMHOLT. Edited by Carl Siewers. Two vols. [Sampson Low, Marston, Searle, and Rivington. 1885.]

One of the first of Nature's wonders to fascinate the eye of the beholder will ever be the aurora borealis. The only grand illustration of the phenomena that it has been the present writer's lot to witness was in years gone by, when one Sunday evening the villagers congregated together outside the school room—then used as a temporary church—and foretold in awe-struck tone how the sky indicated the sanguinary fighting in the Crimea. Days or weeks afterwards it was known that one of the sternest battles ever fought was in progress at the same time as the grand auroral display was seen in central England. From then till now any information concerning auroras has always been interesting and attractive. Doubtless the desire to obtain knowledge on this fascinating subject is widespread. The volumes before us are valuable from a twofold point of view. They not only deal with a purely scientific question, but describe the author's sojourn among a little known and a somewhat despised people. "It is (preface) not a scientific treatise, nor a novel, but merely a modest narrative of a year's sojourn in the distant regions of *Ultima Thule;* not related with pedantic prolixity or tedious erudition, but sketched, as far as in his power, with light and rapid strokes." Let us at once say that the major part of the work consists of an exceptionally readable narrative of a journey to the extreme north of Europe, and a year's residence among the Lapps, in order to investigate the auroral phenomena which are to be seen in all their perfection only in those regions. Notwithstanding our desire to learn about the aurora, we must confess that the author interests us just as much in his narrative as in his purely scientific research. The description is admirable, and in imagination we have experienced the first drive with a reindeer, and the hospitality of the Lapps—the actualities of either we would rather be excused. The work is filled with pleasant anecdotes, one of which we may venture to give. The author desired to see one of the traditional idols. He tried once and failed, because of the incapacity of his guide. The second time he was successful; coming, however, to the conclusion that the stone was merely a common boulder.

"That the stone nevertheless was an idol in heathen times there cannot be the least doubt, because that is proved by tradition, the locality so greatly favoured by Nature, and by the fact that not many years ago there were still large quantities of bones of sacrificed reindeer lying around it.

"As there was no particular reason for having the stone removed, I decided to take a photograph of it. Lars pointed out to me that the stone originally stood erect a few paces from where it now lay, and as I desired to take it in its original position, I requested him to assist me in moving it. After a good deal of toil, as it was very heavy, we succeeded with our three arms in getting it into a pulk and dragging it to the top of a little eminence, where it had no doubt stood in the Pagan days when the Lapps worshipped it as a god or a symbol of divinity.

"At that moment occurred what certainly may be regarded as a remarkable coincidence. Whilst engaged in moving the old god I paid no attention to the weather, which up to then was clear and bright. In the meanwhile it had, however, become rapidly overcast, and when I now looked up, heavy, threatening clouds came drifting over the sky, followed by sudden gusts of wind. I nevertheless unpacked my apparatus, but the wind increased every second, and in less than three minutes we were in the midst of a violent snow-storm. I had just screwed the camera on, and turned round to say something to Lars, when a violent blast overturned the apparatus—and the camera was smashed to atoms against a projecting stone. The whole was the work of a moment, and the incident is the cause of my not having an illustration of the Sieite to place before the reader.

"I looked at Lars Gaino. He shook his head gravely, and said that there existed a belief amongst his people that ill would befall him who meddled with the old gods. There was not one of his race, he said, who did not believe that this was the reason why I was nearly killed when I last visited the mountain, and he was quite sure that the old god had raised the storm and destroyed the wicked apparatus. He desired at once to leave the mountain.

"It seemed, indeed, as if there was something more in what Lars said, for as soon as we were again on our way down the clouds cleared, the sun shone brightly, and there was no more wind than in a cupboard. This fully confirmed Lars and his tribe in their belief.

"The old god was, I regret to say, not satisfied with the destruction he had already wrought, but attempted to drown me as we drove home on the river. It was dark and late, and I had let the rein of my animal be tied to Lars' pulk and gone to sleep. Suddenly I awoke through a violent shock, and, opening my eyes, saw water on both sides of the pulk. It had got into a hole in the ice, over which lay a thin layer of snow, and by the sudden stoppage the rein broke. Fortunately the pulk was a little longer than the hole, so I escaped with a momentary frightening and a cold bath.

"For the future I shall leave all Sieites in peace."

The *raison d'être* for noticing this work must not be forgotten. It, of course, is the confirmation given relating to auroras. M. Tromholt made his investigations at Koutokæino in order to obtain, if possible, a solution of the problem as to the height of the aurora borealis. Another observing station was at Bossekop, some sixty-three miles north as the crow flies. The observations made at these stations, north-south of each other, enabled the necessary data for the calculation to be obtained. The phenomena to be investigated is thus referred to: "The aurora borealis develops a richness of colour and display of light of which those who have only seen this phenomena in southern climes can form no idea. It is nearly always in the sky; as soon as daylight disappears it flames up, and is even transparent when the sky is perfectly obscured by clouds. It is not, as further south, confined to the northern horizon; it is seen in the zenith, and from time to time the waves of light roll symmetrically over the entire sky into the furthest corner of the heavens. That wonderful form of the aurora borealis known as the auroral corona, created by beams or streamers travelling upwards from all points of the horizon and meeting in one spot in the zenith, is also seen here nightly, while another of true Arctic character, the streamers, attains the most marvellous forms. From one side of the sky to another a drapery, woven of light and colour, is wafted; now here, now there, first one, then two, then several bands, one above the other, never at rest and never the same form, hither and thither the folds sway with a soft fascinating motion, as from one end to the other waves of light chase each other, over taking, crossing, meeting, while the lower intense border displays the loveliest colours of red and green, the upper one fading into the dark background." (Vol. I., pp. 89 90.)

It is not, however, till we reach Chapter X. that we find more than casual references to the author's work.

In this portion of the book the author commences by pointing out that writers have been too apt to form theories without any due knowledge of the facts relating to the phenomena. Thus, he says, "Without any knowledge of the phenomenon one compiler copies from another the correct with the incorrect, and in the course of time the auroral literature has become so inundated with what may be called 'traditional falsehoods,' that it would be a herculean task to cleanse these Augean stables." He describes the principal forms of the aurora, giving admirable illustrations here, as indeed in all other parts of the book, showing how the many different forms seen by observers are really to be reduced to a few fundamental ones, the variety being due to the difference in the positions of the observers. He combats many of the errors which have crept into the literature, such as the clicking noise said to be heard during the prevalence of these displays and the amount of light received from the aurora. As regards the latter, he maintains that though for a few moments the light may be very intense and cast an unusual brightness over the landscape, these intervals of luminosity are so brief that the light emitted is of no practical value to the inhabi-

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tants of the Polar regions. So far as M. Tromholt is concerned he is very emphatic against any noise of any kind being heard during the auroral display. We cannot enter into questions relating to the disturbance of aurora or the height; suffice it for us to say that on the latter point M. Tromholt—so far as his investigations have gone—seems to place it as about from 70 to 80 miles. Thus, he says (p. 259, Vol. I.), taking the average of 18 measurements: "The average height of the lower edge will be 70·2 miles, a result in perfect harmony with later observations." According to our author, the aurora borealis has three distinct periods, daily, yearly, and eleven-yearly; and he considers that these periods are connected with phenomena far beyond the earth's sphere, viz., the so-called solar disturbances (p. 265). The author almost refuses to be led into discussion of theory, pointing out that, though the knowledge obtained by scientific investigation has perhaps enabled us to see what the aurora borealis is not, at present we are totally unable to say what it is; but he admits that the phenomena is probably of an electrical character, and that the theory which seems to deserve most adherence is that advanced by Prof. Edlund, of Stockholm (p. 286). Our space will prevent us saying more upon these very interesting volumes, though we must not forget to state that they are exceedingly well illustrated, and accompanied by a map showing the routes and the localities visited during these investigations. The book will be of interest to the geographical and ethnographical student hardly less than to the electrical.

THE KAUFFER AND GOLDNER BATTERY.

On July 7, at 12 midnight (says an American contemporary) a battery of nine cells was started lighting two 8 candle-power lamps, six minutes on and six minutes off, day and night, the interruptions being accomplished by the aid of an ordinary 24-hour clock. This was continued until July 20, at 10 a.m., when the lamps had been burning a total of 152 hours. The object of this arrangement was to get the 152 hours inside of twelve days, while in practice they would be spread over six weeks. It was found on July 20 that the battery was by no means exhausted, so without any renewal of the depolarising liquid it was started on a consecutive run. At the end of the 152 hours ½lb. of zinc had been consumed in each cell, making the cost of zinc for the nine cells 45 cents. The inventors, Messrs. Kauffer and Goldner, state that the work put upon the battery in the test described was harder than it would have been if running, according to their original claim, four hours a day for a period of 38 days. The test has been watched with much interest, and was carried out by parties other than the inventors themselves.

THE INTERNATIONAL TELEGRAPH CONFERENCE AT BERLIN.

The opening meeting of the International Telegraph Conference took place at noon on Monday, the 10th instant, in the large lecture hall of the Post Office Department in the Artillery Strasse. Thirty-three States and 17 cable companies were represented. In all 72 delegates were present. England is represented by Mr. C. H. B. Patey, and Messrs. Fischer and Benton, of the Post Office Telegraph Department; France, by M. Fribourg, Director of Telegraphs, and MM. Lorin and Brunet; Austria-Hungary, by Baron von Watenwyl, Director-General, and two Councillors of the Telegraph Department; Russia, by General von Besack, Chief of the Telegraph Department, and two assistants; Italy, by Signor d'Amico; Spain, by Señor Aquilino Herce and Señor Coromina; Switzerland, by M. Frey; Turkey, by her Ambassador at Berlin; and all other European States by the principal officials of their Postal and Telegraph Departments. Of extra-European countries the following are represented:—Algiers, Brazil (Senhor Capanema), Cochin China, the Dutch East Indies, Egypt (Mr. Floyer), Japan, Persia (Colonel Smith), and Siam (Prince Prisdang, assisted by Mr. Wilberforce Wyke); and also British India (Colonel Bateman-Champain and Mr. C. H. Reynolds), and the following British Colonies:—Cape Colony, Natal, New Zealand, South Australia (Mr. C. Todd, the Postmaster-General), Victoria, New South Wales (Mr. E. C. Cracknell), and Tasmania (Mr. J. Henniker Heaton). The two last-named colonies notified their adherence to the Union only a few days before the opening of the Conference. Besides these official representatives, the following fifteen large cable companies, which occupy an international position, are also represented by special delegates:—

Company.	*Delegates.*
Eastern, Eastern Extension, Australasia, and China, Eastern and South African, Black Sea	Mr. John Pender, M.P. (chairman); Sir James Anderson (managing director); and Mr. Lewis Wells.
The Anglo American	Mr. Henry Weaver and M. Jules Despecher.
Submarine	Sir Julian Goldsmid, Bart. (chairman); Herr G. von Bunsen.
Indo-European	Mr. W. Andrews (managing director); Mr. F. Moll (secretary).
Great Northern	Capt. E. Suenson, of Copenhagen (managing director); Capt. W. de Hedemann (company's agent, in St. Petersburg); and Mr. F. C. C. Nielsen (manager of London office).
German United	
Compagnie Française	
Direct United States	Mr. John Pender, M.P. (chairman); Mr. J. W. Fuller (secretary and traffic manager).
Brazilian Submarine	Mr. Thomas Fuller (managing director).
Direct Spanish	Sir James Anderson (chairman) and Mr. C. Gerhardi (manager).
West India and Panama	Mr. W. Andrews and Mr. Henry Weaver.
Western and Brazilian	Major A. Wood (managing director).

The present Conference is the seventh of its kind. The first International Telegraph Conference met by invitation of the Belgian Government at Brussels in 1858, and adopted the fundamental regulations of the International Telegraph Convention. The second conference at Paris in 1865 amended and completed these regulations, and also adopted a resolution fixing the meetings of the conference at regular intervals in one of the European capitals. At Vienna, in 1868, the first extra-European countries (Asiatic Russia and British India) were admitted to the Union, the International Convention was finally adopted with 67 articles; and the International Telegraph Bureau at Berne was established. At Rome, in 1872, the Convention was further amended, and delegates of the cable companies were first admitted. The fifth conference, at St. Petersburg in 1875, passed new statutes and a general reduction of the tariff; and the sixth, at London in 1879, adopted the general word-tariff for international telegraphic intercourse. At all of these Conferences each State, although represented in most cases by several delegates, was entitled only to one vote, while the cable companies had no voting powers. The proceedings of the seventh Conference, which began on Monday, is conducted, like all the former ones, in the French language, as also the protocols and official reports of the Conference. The German Postmaster-General, Dr. von Stephan, Secretary of State, is the president. The main subject to be discussed by the present Conference is the general tariff question, and the regulation of international rates and charges, which has already occupied the attention of former Conferences. The States which favour a considerable reduction of rates still appear to be in the minority. Russia particularly opposes all proposals for reducing the tariff, as involving a great deficit in the receipts, and a large number of the other States, together with the cable companies, follow the same policy. The following proposals, however, will be discussed and voted upon by the Conference.

1. Germany proposes to establish a uniform tariff for all Europe, similar to the common rates now in force throughout the Universal Postal Union, of, say, 50 centimes fee for each message, and 20 centimes per word; or 10 centimes between countries bordering on each other. Messages by submarine cables to be subject to special rates. Germany also wishes to abolish the free transmission of date and time as hitherto. 2. Austria-Hungary also proposes a reduced tariff and a new system of settling accounts between the members of the Union; and also moves for a reduction of rates for newspaper messages. 3. England proposes to abolish all messages containing only the address and signature, but no other contents. 4. Belgium wishes to limit single words in extra-European messages to fifteen letters and five figures. 5. The Netherlands move to abolish the fixed number of words for prepaid reply messages. Another proposal is to levy charges, not as hitherto, on the number of words, but on that of the letters and figures. Besides the foregoing measures of administration, it

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is also proposed to lay a number of technical questions relating to the latest results of telegraphic and electrical science before the Conference. For this purpose a series of highly interesting and important experiments will be carried out in the Central Telegraph Station in the Oberwallstrasse, the large apparatus hall of which probably surpasses in completeness those of all other Continental capitals. These experiments, which promise results of great scientific importance, will also be attended by the best authorities on electricity and telegraphs, viz., Mr. Werner Siemens, Mr. John Pender, M.P.; Sir James Anderson, Sir Julian Goldsmid, M. Jules Despecher, Captain Suenson, and others.

Dr. von Stephan opened the Conference after a speech in which he welcomed the delegates in the name of the Kaiser, and stated that this Conference would continue in common the labour of further perfecting the powerful means of communicating thought and extending civilisation which science has secured for mankind. Mr. Patey, one of the English delegates, representing all the others, briefly expressed their thanks for the welcome accorded to them, paying a complimentary tribute to Dr. Stephan, whom he proposed as president. Herr Hake, a director in the German Post Office, was elected vice-president, and the bureau was composed of M. Curchod, director of the International Telegraphic Bureau at Berne, with Herr Eschbaecker, secretary of the Bureau International, and Herren Linz and Neumann, of the German Post Office, as secretaries. Dr. Stephan referred to those members of the last conference who had died, amongst whom was Sir William Siemens. He also paid a warm tribute to the memory of the late Mr. Fawcett, at the mention of whose name the assembled delegates rose from their seats in token of respect. Speaking of the work that lay before the delegates, Dr. Stephan said that the London Conference established the principle of the word-rate, and it was to be hoped that the Conference which had just met would be able to record as the result of its labours another step in advance, particularly in the direction of bringing the telegraph into the service of a still larger public, and increasing its accessibility to all, even to the less wealthy classes of the community. With the maintenance of that spirit of conciliation which had been manifested at all conferences hitherto, and had made it possible to unite in the adoption of a common code of principles such a vast number of telegraph systems spread over the whole earth and governed by such diverse conditions of organisation, he doubted not that any new difficulties presenting themselves would be surmounted in the course of the forthcoming interchange of views.

Mr. Fischer, another of the English delegates, then gave an account of England's administration since the last Conference, after which Director-General Kielson (Norway) gave a review of the results of former Conferences. Professor Curchov, head of the International Bureau, read a report upon a proposal relative to the compilation of statistics of electrical measurements, and the effects of atmospheric currents and thunderstorms.

Two committees were afterwards formed, one to consider the tariff question, and the other the regulations, &c., these committees comprising eighteen and ten members respectively.

In the Committee on Tariffs, consisting of delegates of Germany, Austro-Hungary, Belgium, Denmark, Spain, France, Great Britain, Italy, Japan, Luxemburg, Norway, Netherlands, Portugal, Russia, Sweden, Switzerland, and Turkey, the Austrian delegate, Baron Brunner, has been appointed President, the Italian delegate, Signor Amico, Vice-President, and the French delegate, Director-General Fribourg, Referee. The fact that a German delegate was not appointed chairman is regarded as ominous of the rejection of the proposal made by Germany in favour of a sweeping reduction of charges. An American delegate on Tuesday made a very eloquent speech in support of the German proposal, but it is believed that the opposition of Russia, Turkey, and the great cable companies will be fatal to the German scheme. The other Committee, which has to deal with the regulations on technical and administrative matters, consists of delegates of Germany, Belgium, Brazil, France, Great Britain, Roumania, Sweden, Portugal, Russia, and British India. The President is Director Hake, of Berlin; the Vice-President, the Brazilian delegate, Baron Capanema; and the Referee, the Belgian Director, Delarge.

Renewed doubts are expressed as to the success of Germany's proposal for the introduction of a reduced European tariff, as this could not very well harmonise with the interests of the private English companies, to speak of nothing else, and it is understood that on this ground more particularly the British delegate will be forced to reassert the negative standpoint assumed by England at the London Conference. The only solution of the difficulty, *The Times* remarks, would be a guarantee on the part of the Continental Powers, or some of them, that under the proposed new system the revenues of the English companies should not be less than they are at present, but little hope is entertained that a compromise of this kind will be arrived at. One delegate for each State is entitled to vote. The rest, whether representing States or companies, have only a deliberative voice. The chief feature of the hall in which the delegates meet is a large telegraphic map of the world, which has been specially prepared for the purpose by the helpers of Dr. von Stephan.

On Monday next the delegates will be entertained at a banquet in the Zoological Gardens by the United German Telegraph Company, while they will likewise be treated to an aquatic excursion and a supper by the City of Berlin.

AWARDS AT THE INVENTIONS EXHIBITION.

Gold Medals.

Adamson, Daniel, and Co., "Wheelock" automatic cut-off engine.
Bell, John, and Co., treatment of asbestos.
Buckton, J., and Co., testing machine with autographic indicator.
Cardew, Captain, voltmeter.
Crompton, R. E., and Co., improvement in electric lighting appliances.
Crookes, William, radiometers, &c.
Crossley Brothers, gas engines.
Davey, Paxman and Co., engines and boilers.
Doulton and Co., general exhibit of pottery, &c.
Edison and Swan United Electric Light Company (Limited), Edison-Swan systems of electric lighting.
Electrical Power Storage Company, improvements in secondary batteries.
Fielding and Platt, high-speed engine.
Galloway, W. and J., and Sons, engines and boilers.
Goulard and Gibbs, successful working out of a system of distribution of electricity by induced currents.
Greenwood and Batley, high-speed horizontal engine.
Hathorn, Davey and Co., domestic motor.
Heenan and Froude, "Tower" spherical engine.
Henley's, W. T., Telegraph Works Company (Limited), excellence of cables.
Hick, Hargreaves, and Co., "Corliss" engine.
Hicks, J. J., improvements in thermometers, and other philosophical instruments.
India Rubber and Gutta Percha and Telegraph Works Company (Limited), india rubber and gutta percha.
Jenkin, Professor Fleeming (the late), telpherage.
Kitson and Co., Parson's high-speed engine.
M'Kenzie and Holland, railway signals, points, and crossings.
Phosphor Bronze Company, phosphor bronze alloys.
Planté, G. (France), secondary battery and scientific research.
Ransomes, Sims, and Jeffries (Limited), machinery.
Saxby and Farmer, railway signals and safety appliances.
Scott, Ernest, Ashton's positive actioned power meter and continuous indicator.
Shaw, Professor W. S. Hele, sphere and roller mechanism for transmission of power.
Shaw, Professor, W. S. Hele, improved integrators.
Siemens Brothers and Co., excellence of electric lighting arrangements.
Sterne, L., and Co., gas engines.
Swan, J. W., incandescent lamps.
Sykes, W. R., combined electric interlocking and blocking system for railways.
Thomson and Houston, systems of electric lighting. (Exhibited by Laing, Wharton, and Down.)
Varley, S. A., designing the first self-exciting dynamo machine.
Warne, W., and Co., india rubber.
Watkin, Major H., R.A., ingenuity in devising and applying practically scientific and accurate instruments to various military purposes, and the electric light for powder factories.
Watson, Laidlaw and Co., self-balancing centrifugal machine and hydro-extractor (Weston's patent); self-balancing electro-centrifugal machine and hydro-extractor (Watts' patent).
Westinghouse Brake Company (Limited), automatic air-brake and passenger communication for railway trains.
Wilde, Henry, discovery of the indefinite increase of the magnetic and electric forces from quantities indefinitely small.
Willans and Robinson, Willans' compound engine and electric governor.

Silver Medals.

Allen, W. H., and Co., high-speed engine and dynamo.
Alley and Maclellan, high-speed engine.
Andrew, J. E. H., and Co., gas engines.
Arundel and Co., Moscrop's continuous engine speed recorder.
Asbestos Company (Limited), asbestos packing.
Bernstein Electrical Lamp Company, incandescent lamps.
Boake, A., and Co., manufacture of sulphurous acid and sulphites.
Bower, George, process for rendering iron rustless.
Brin Frères, improvements in the production of oxygen and nitrogen gases.
Chapman and Messel, improvements in the manufacture of anhydrous sulphuric acid.
Chipperfield, R., good workmanship of engineering models.
Condy, H. B., manufacture of permanganates, hyposulphates, &c.
Consolidated Electric Light Company, system of using secondary batteries.
Deakin, Parker, and Co., Acme high-speed governor.
De Ferranti, S. Z., electric meter.
De Gruyter Clock Manufacturing Company, application of torsion to the measurement of time.
Delany Synchronous Multiplex Telegraph System, multiplex telegraphy.
Electric Sun Lamp Company, electrical exhibit.
Elwell and Parker, dynamo machine.
Faraday and Son, electrical fittings.
Fergusson, H. A., Lalande-Spence battery.
Gamble, Jos., and Sons, manufacture of chlorate of sodium, &c.

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Gaussen, D., "V.W.H." corrugated vulcanised india rubber for various purposes.
Gerard and Co. (Limited), lamps and dynamos.
Glover, W. T., and Co., cables.
Goodfellow and Matthews, high-speed compound tandem engine.
Groves, William, construction of electrical and philosophical apparatus.
Gülcher Electric Light and Power Company (Limited), electric lighting apparatus.
Harper, —, patent electrical block system.
Harrison, Cox-Walker, and Co., electrical exhibit.
Howard and Sons, pharmaceutical preparations.
Immisch, M., improvements in electric motors.
Jablockkoff and General Electricity Company (Limited), Jablochkoff system of electric lighting.
Kendall, J. A., gas battery.
London Water Meter Supply Company, rotary meters and "Daussin" domestic motor.
Manganese Bronze Company, manganese bronze.
Marshall, Sons, and Co., high-speed engine.
Mather and Platt, high-speed engine and dynamo.
Maxim-Weston Electric Light Company, electrical exhibit.
Miller, Leslie B., electrical exhibit.
Muspratt, James, and Sons, improvements in the manufacture of chloride of potassium.
Nicholson, W. N., and Sons, steam engines.
Parkes, Alexander, insulating materials.
Parsons, Hon. E., electric governor and dynamo.
Pilsen-Joel and General Electric Light Company (Limited), Pilsen lamp.
Rigg, James, models of machine construction.
Robey and Co., improved Robey winding engine and horizontal fixed engine.
Salomons, Sir David, Bart., electrical appliances and philosophical instruments.
Scott, Ernest, and Co., machine for extracting iron from other substances by means of electro-magnetism.
Smith, Rev. F. J., ergometer and integrating instruments.
Smith, M. Holroyd, electric tramway.
Smith, J., and Sons, electric time balls.
Standard Time and Telephone Company (Limited), method of synchronising clocks.
Stephen, J., synchronic call.
Swan, Alfred, electric safety lamp.
Thurston and Co., electric billiard marker.
Traill, W. A., electric tramway.
Trouvé, G., electrical appliances.
Voss, Robert, induction machine.
Welch, E. J. Cowling, and W. Parker Smith, automatic brake.
Woodhouse and Rawson, electrical exhibit.
Yeates and Son, standard pressure gauge, &c.
Young, John, speed indicator.

Bronze Medals.

Allin, S. S., signal wire compensator.
Almqvist, Fridolf (Sweden), governor and speed indicator.
Andrews, J. D. F., and Co., electrical exhibit.
Anglo-American Brush Electric Light Corporation (Limited), electric lighting apparatus.
Beynon and Cox, patent gas engine.
Botten, H., electrical exhibit.
Brown, A. C., electrical exhibit.
Cassel, H. R., method of extracting gold from refractory ores by electrolysis.
Cobbett, W. Wilson, cotton machine belting.
Cordner, Allen, and Co. (Limited), electrical exhibit.
Coxeter and Nehmer, electrical exhibit.
Dale, H. and E. J., electrical exhibit.
Danchell, F. H., electrical exhibit.
Davis and Timmins (Limited), electrical exhibit.
Delepine, S., microtome.
Electric Signal Company (Limited), system of railway signalling.
Electro-Amalgamator Company (Limited), electro-amalgamator.
Fisher and Mieg (Austria-Hungary), hard porcelain.
Gant, R. B., electrical exhibit.
Globe Electrical and Engineering Company, electrical exhibit.
Goolden and Trotter, electrical exhibit.
Gray, J. W., and Son, electrical exhibit.
Harling, W. H., improvements in mathematical instruments.
Hockey and Co., Hockey's patent rotary engine.
Holmes, J. H. and Co., electrical exhibit.
Irish, W. E., electrical exhibit.
Jack, James H., electrical exhibit.
Jeffrey and Blackstone, portable vertical steam engine.
Joel, Henry Francis, electrical exhibit.
Kato Jukichi, porcelain lamp stands.
Korting Brothers, gas engine.
Lee, R. A., electrical exhibit.
Lorrain, J. G., electrical exhibit.
Lundberg, André Peter, electric lighting.
Macdonald, J. H. A., electrical exhibit.
Mackie, W., electrical exhibit.
March, Octavius, electrical exhibit.
Marshall, J. T., and Co., compound semi-fixed engine and boiler.
Moore, George, clock with electric alarum attachment.
Mosses and Mitchell, vulcanised fibre.
Munden, William John, gas engines.
Munro, John, electrical exhibit.
Ogden, Ralph, Manchester automatic expansive steam engine.
Oldfield and Walton, link belting.
Paterson and Cooper, electrical exhibit.
Perkins, A. M., and Sons, high-pressure engine and boiler and evaporative surface condenser.
Perry, A. H., electrical exhibit.
Phillips, F. C., electrical exhibit.
Pinchbeck, J., rotary steam engine.
Richardson, John, steam engine indicator for taking continuous diagrams.
Richardson, Koolman, and Isger, electro-plates and moulds.
Riley, John, electrical exhibit.
Rogers, Francis, M., electrical exhibit.
Scott-Moncrieff, W. D., steam engine governor.
Sellars, J. C., electrical exhibit.
Sennett, A. R., and Co., electrical exhibit.
Shepherd, C., improvements in electrical and sympathetic clocks.
Shippey Brothers, electrical exhibit.
Smith, T. Taylor, electrical exhibit.
Stewart, Charles W., electrical exhibit.
Thompson, Dowsing, and Rew, electrical exhibit.
Thorpe, H., electrical exhibit.
Timmis, I. Augustus, railway signals and points.
Trott, H., and Fenton, electrical exhibit.
Van der Weyde, electrical illumination of the sitter in photographic portraiture.
Vulcan Manufacturing Company, electrical exhibit.
Wilson, J. Veitch, and Co., improvements in the manufacture of lubricating oils.
Wood, Miss, geometrical ruler.

Society of Arts Medals.

Crookes, William, F.R.S., for his improvements in apparatus for the production of high vacua, and for his invention of the radiometer. *(Under the Fothergill Trust.)*
Crossley Brothers, for the Otto gas engine. *(Under the Howard Trust.)*
Hathorn, Davey, and Co., for their domestic motor. *(Under the Howard Trust.)*

Diplomas of Honour

which have been accorded only to Government Departments and public institutions:—

Japanese Government Education Department, Tokio, Professor Ewing's seismometers and other scientific instruments.
Japanese Government Telegraph Department, excellent workmanship and design of electrical and telegraph instruments.
Kew Committee of the Royal Society, system of testing watches, instrument testing, &c.
Physical Society of London, collective exhibit.
Royal Meteorological Society, meteorological apparatus.
Royal Engineers' Establishment. Chatham, (1) employment of cheap mirrors for the electric light, (2) application of the vibrator, (3) Cardew's voltmeter, (4) toughness and lightness of the material employed for military balloons and its capability of retaining hydrogen gas, (5) the use of tubes for the storage of hydrogen gas under high pressure for balloon inflation.

CITY GUILDS EXAMINATIONS.

The following is a list of the names of those gentlemen who satisfied the Examiners at the late May examinations:—

Electric Lighting.

Bacot, Edmund A., London.
Bennie, Hugh O., Glasgow (2nd, £3, and bronze medal).
Bigger, Fred. C., Glasgow.
Bigg-Wither, Frank H., London.
Bowron, Geo., London.
Briscoe, Albert E., Birmingham.
Bryan, Frank, Manchester.
Burton, Jas. E., London.
Chatterton, Alfred, London.
Coote, Ernest R., London.
Crawshaw, W. S., London.
Dalby, Edward C. B. E, London (4th, £1, and bronze medal).
Davidson, Louis, London.
Duffitt, George, London.
Filer, Frank E., London.
Fisken, Jno. B., Glasgow.
Fulton, Thos. C., Glasgow.
Fussell, Joseph H., Nottingham.
Gutman, Ludwig, London.
Hird, Arthur, Leeds.
Jenkins, Hy. C., London (2nd, £5, and bronze medal).
Kober, Charles, Glasgow.
Lea, Frank B., Manchester.
Leake, Walter, Manchester.
Marks, Herbert T., London.
Marshall, Geoffrey, Glasgow.
McMillan, Jno., Glasgow.
Mitchell, Geo. A., Glasgow.
Moon, Jno. S., London.
Morton, Wm. D., Glasgow.
Newbury, Fred. E., London.
Pyall, Wm. A., London.
Raine, Abraham D., London.
Sanderman, Jas., Glasgow.
Schmitz, Herman E., Leeds.
Seward, Willis G., London.
Slater, Arthur W., London.
Shaw, A. H., Manchester.
Sheard, Arthur H., London.
Snell, Albion T., London.
Spence, W. Lawson, Manchester.
Stocken, A. L., London.
Swan, Howard, London.
Thomas, Bertram, London.
Thomas, Eustace, London.
Tonge, Jno. H., London.
Turvey, Wm., London.
Wardell, Thos., Glasgow.
Wallich, Horace, London.
Wallis, T. M. W., Nottingham.
Wilson, Ernest, Leeds.
Wilson, Willie H. de M., London.
Wood, Harry, Manchester.
Woodward, J. H., Manchester.
Young, Benjamin, Belfast.

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Telegraphy.

Aldworth, Jno. R. O., Cardiff.
Baguley, Joshua, Manchester.
Beach, Hy. S. W., London.
Bell, Henry S., Dublin.
Bennett, G. F., London.
Bennett, H. W., Nottingham.
Billingham, G. W., Birmingham.
Blackburn, Richd. S., London.
Brown, Wm., Aberdeen (4th, £1, and bronze medal).
Brooker, Arthur (2nd, £3, and bronze medal).
Butler, F. W., London.
Butler, Wm. H., London.
Campbell, Duncan, Glasgow.
Carter, Edwd. T., Bristol.
Chapman, Albert, Manchester.
Clayton, Birmingham.
Collinson, T., Newcastle-on-Tyne.
Cochrane, Jas., Manchester.
Connell, Geo. W., London.
Connolly, Wm., Dublin.
Crombie, Jas., Glasgow.
Curran, Patrick J., Dublin (3rd, £2, and bronze medal).
Delahunty, Timothy.
Dorman, Geo. H., Birmingham.
Ferguson, Jas., Newcastle-on-Tyne.
Fogarty, Jas., Dublin.
Fraser, Andrew, Aberdeen.
Fraser, James, Aberdeen.
Gaiter, John, Aberdeen.
Gifford, James, Glasgow.
Greenwood, Arthur, Bradford.
Haigh, Joseph S., Bradford.
Hall, Geo., Manchester.
Harrison, Wm. S., Manchester (1st, £5, and silver medal).
Hendrie, Robt., London.
Hills, Wm. F., London.
Hodgkinson, Arnold, Manchester.
Kennedy, Wm., Aberdeen.
Leonard, Wm., Dublin.
Levingstone, Joseph, Dublin.
Lloyd, Edgar W., Nottingham.
Macfee, Jno., jun., Glasgow.
Mansbridge, Geo. F., London (2nd, £5, and bronze medal).
Marshall, Jno. W., Manchester.
M'Candlish, Albert, Manchester.
M'Lachlan, Robert J., Glasgow.
Mitchell, Jas., Dublin.
Murray, Wm. F., Dublin.
Noble, Wm., Aberdeen.
Philpott, Jas. J., London.
Pickering, Jas. R., London (1st, £3, and silver medal).
Pigg, Jas., Newcastle-on-Tyne.
Plummer, Thos., Wexford.
Pollard, Fredk., London.
Prince, Wm. T., Wolverton.
Rickwood, Hugh, Manchester.
Saul, Frances Mary, Belfast.
Smyth, Wm., Dublin.
Taylor, Chas., Dublin.
Taylor, Jas. F., Manchester.
Tremain, Francis, Plymouth.
Tucker, Wm. S., Liskeard.
Turner, Jno. W., Plymouth.
Wilkes, Albert, Bradford.
Wilson, Hugh, Glasgow.
Winn, Chas. W., London.
Wood, Henry G., London.
Worsley, W. A., Manchester.

Electro-Metallurgy.

Brown, Geo. A., Birmingham (2nd, £3, and bronze medal).
Buchan, Alexander, Glasgow.
Buckeridge, H. L., London.
Bush, Wm., Newport, Mon.
Clarke, Chas. W., Birmingham.
Coldwell, R. N., London.
Dryhurst, Jno., Birmingham.
Gower, Alfred R., Birmingham.
Hurtley, Wm. H., Leeds.
Kinvig, J. W. B., Neath.
Macaulay, Malcolm.
Parker, Williamm Joseph, Birmingham.
Partridge, Wm. J., Birmingham.
Taylor, Robert, London.

Electric Instrument Making.

Fishenden, Edward G., London.

LEGAL.

United Telephone Company (Limited) v. Bassano and another.

In the High Court of Justice, before Mr. Justice North, on Wednesday last, this action was mentioned, his lordship reserving the delivery of his full judgment until after the Long Vacation. The hearing occupied the Court for several days during last month (reports of the proceedings appeared in *The Electrician* from week to week), the main issue being as to the infringement by the defendants of that portion of the Edison telephone which is known as the "transmitter," and the patent for which is the property of the plaintiffs.

The Attorney-General, Mr. Aston, Q.C., Mr. Moulton, Q.C., and Mr. Micklem were for the plaintiffs; Mr. Bigham, Q.C., Mr. C. Plumptre, and Mr. John A. Hamilton for the defendants.

His LORDSHIP said that, although he had not been able to find the time to write out his considered judgment, he would without further delay state that he had decided the case in favour of the plaintiffs, and he therefore granted them an injunction to restrain the infringement, and an order for delivery up of the offending machines.

The plaintiffs' solicitors undertook that the latter should not be destroyed during the vacation.

COMPANIES' MEETINGS.

The National Telephone Company (Limited).

The fifth annual ordinary general meeting of the shareholders was held on the 7th inst. at the offices of the company, 11, Queen Victoria-street, Colonel R. Raynsford Jackson, the chairman of the Company, presiding.

The notice calling the meeting was read by Mr. WILLIAM B. CAMPBELL, the secretary.

The report, which was taken as read, recommended a dividend at the rate of 2½ per cent. per annum on the ordinary capital for the second half of the year, in addition to the interim dividend for the first half of the year at the rate of 2 per cent. The accrued interest on the debentures, and the usual dividend of 6 per cent. on the preference shares, was also provided for.

The CHAIRMAN said: Gentlemen, I shall move the adoption by the shareholders of the Directors' report, and shall occupy your attention only an extremely short time, because the reports and accounts of the Company are complete in themselves, and put you in possession of all that it is necessary you should know respecting its affairs. I will, however, for a reason which will afterwards appear, call your attention to the increase in the gross revenue of the Company. You will see that on the 30th June, 1884, the gross revenue had reached £57,271. 15s. 2d., and that on the 30th June last it had reached £70,943. 11s. 3d. You will see, therefore, that there is a considerable increase in the gross revenue, and I am happy to say that the increase in the net revenue has been relatively greater. The net revenue for 1884 was £15,227. 0s. 5d., and for the year ended 30th June last £23,658. 10s. 3d. I have only called your attention to these figures because I wish to point out to you that no increase of the revenue of a telephone company can take place without an expenditure of capital. A telephone company is in a different position to almost any other undertaking in that respect. Take, for example, a railway. When a railway has been constructed at a given expenditure for the railway itself and for the plant, the traffic may be large or it may be small, and it may grow very considerably without the investment of additional capital. On the other hand, in a telephone company, if you obtain an additional number of subscribers, you can only connect them with the telephone system by an outlay for wires, standards, plant, &c., which necessarily involves the investment of capital. So, if you wish for any large increase of the revenue, you can only obtain it by corresponding investments of money. You may therefore, I think, safely assume that if a telephone company is properly conducted, and if its capital is soundly invested, then the amount of capital devoted to the development of its business is a fair criterion of the success of the company. I beg to inform you, although most of you, I think, will have received the circular containing the resolutions which will be proposed at a meeting to be held next Tuesday, that on that day a proposal will be put before the shareholders for an increase of the capital of this Company, and the effect of your sanction to the issue of that additional capital, and of its investment, will be doubtless to increase the prosperity of the Company, and to add to the dividend on the ordinary shares. The capital expended during the last year was £53,290. 17s 1d. That was a larger amount considerably than in the previous year, and I think the shareholders may naturally inquire why the larger amount has been spent. You are aware that the license of the Postmaster-General, under which the Company carries on its business, was altered last year, and that larger powers were given to the companies. Amongst those powers was the right to erect trunk wires in substitution of those previously rented from the Postmaster-General, and to have its own wires to connect town with town. The Company has largely availed itself of the privilege, and spent about £10,000 in doing so. Of course we have not as yet received a satisfactory return upon that expenditure, but the revenue is growing. We have two kinds of trunk traffic—namely, that derived from the ordinary rentals and that from those who pay for fee messages. The latter revenue is steadily increasing from week to week, and there is every prospect of its attaining, in the course of time, a large development, and being a valuable source of income to the Company. When we took over Messrs. Graham's telephone business in Glasgow, he had about 200 subscribers, and it was part of our bargain that he should have the right to erect and maintain our wires in Glasgow and within a radius of twenty-five miles around. But we found that contract disadvantageous, and all the work done under it extremely costly. We therefore entered into negotiations with Messrs. Graham, and bought the contract from them. The purchase of that contract cost us something over £7,500. I congratulate the shareholders upon the completion of that transaction. The effect has been to diminish, to a very great extent, the cost of working the Glasgow system; in mere maintenance alone the saving from that cause has been very large, and the saving in the cost of construction is so considerable that we have undertaken works in connection with our Glasgow district which we certainly should not have ventured to construct had that contract been in existence. You are aware we have acquired considerable additional territory from the United Telephone Company; an expenditure of about £2,200 was involved in connection with the acquisition of that territory. The expenditure proper for the increase of our ordinary revenue was £34,000, and the result of that outlay has been, I think, extremely satisfactory. I only know, so far, of one item of expenditure of importance in the current year. You are aware that we had a serious opposition in Dundee, where there was a rival company called the Dundee and District Telephone Company, and in order to carry on our contest with that company we were obliged to reduce our tariff to the low figure of £5. I need not tell you that we lost money heavily during the continuance of the contest with that company. When I was last in Scotland I succeeded in making an arrangement by which that business was conveyed to us upon payment to the local company of £8,500. By our arrangement with the United Company we are not allowed to possess instruments, but have to use the telephones of the United Company. That company, therefore, took over the instruments, and purchased them from us. So the actual cost of the purchase of the Dundee and District Telephone Company was not excessive, and the effect will be a considerable increase of our revenue from that town, where I have no doubt the company will henceforth possess a valuable telephone property. Dundee is connected with many of the surrounding places by trunk wires, and I do not suppose that there is any telephone system more perfect than that in Dundee and the vicinity. It is connected with Perth, Arbroath, and Forfar, and is about to be con-

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nected with other places. A good deal has been said about the telephone tariffs, and many complain that they are unduly high; but those who make that complaint speak, I think, in ignorance of several important facts. Some of them say that the telephone charges in this country are the highest in the world. They are not aware, perhaps, that there are more telephones in the United States than in all the rest of the world put together. When the telephone was first introduced there, a great many exchanges were started upon low tariffs, and the companies thought they were making very large profits, but in the course of time they found the expenses so much greater than they anticipated that, instead of earning profits, they were losing money, and the effect was a general increase of telephone tariffs in America. I think our subscribers would be somewhat disagreeably surprised if in this country (where we are said to adopt the highest rates) we were to adopt those current in America—that is to say, £35 per subscriber, which is the rate charged in New York, Philadelphia, and other great American towns. The fact is you cannot adopt the same tariff in every town. The cost of working the telephone varies according to an infinite variety of circumstances. In some towns you are obliged to adopt a high tariff, and in others you can work it lower. As far as the National Telephone Company is concerned, it has been its aim to give its services upon economical terms to the subscribers. Therefore, in some places you will find the tariff is remarkably low, and that is due to the fact that we have been able to make it so without disadvantage to the Company. In other towns it is necessarily higher, as the expenses in those towns are greater. I do not think it necessary to dilate further upon this subject, or, indeed, upon any of those matters which interest the shareholders, because as I said in the beginning, our report seems to deal with everything which is of genuine interest. I will therefore say nothing more, unless in answer to questions which may be put by shareholders present. I move the adoption of the report.

Mr. J. P. BIGELOW seconded the motion.

Mr. GEORGE PUGH: With regard to the reserve fund, how is that invested?

The CHAIRMAN: The reserve fund is not specially invested. It is a means of setting aside a certain amount instead of investing it.

Mr. PUGH: Will that be used in the business?

The CHAIRMAN: That will be used in the business; yes.

Mr. PUGH: Then it is only nominally a reserve fund.

The CHAIRMAN: In that sense you may say it is only nominally a reserve fund. It will be used in the business. It is better to use that portion of the earnings in the business rather than to divide it and require further capital. Contingencies are constantly arising which may require expenditure, and it is desirable to set aside a portion of the earnings in this way from time to time.

Mr. PUGH: I understand the value of a reserve fund, but I do not see its value when it is used in this way—in the business.

The CHAIRMAN: Your suggestion is one that the money should be taken out of the business and invested.

Mr. PUGH: Then it would form a reserve fund.

The CHAIRMAN: Your suggestion is one which the Directors will be prepared to consider the same as they would any suggestion from any shareholder, but this is the first time we have set aside anything towards a reserve fund, and it is our intention to continue setting aside certain sums to reserve fund, so as to prevent our spending everything earned by the Company.

A SHAREHOLDER: Undivided profits you had better call it.

The CHAIRMAN: Well, there was a difference of opinion as to whether it should be simply carried forward or set aside as a reserve fund, but the general opinion was that it was better to set it aside as a reserve fund, because then it is regarded as an amount that you cannot touch. Mr. Pugh, you must bear in mind we do not obtain our capital from the public at less than six per cent. If we invest our reserve fund we shall probably not get above four per cent., so that the effect of investing it would be that you would lose two per cent.

Mr. PUGH: I understand it is merely the nucleus of a reserve fund.

The resolution for the adoption of the report and accounts was then put to the meeting and carried unanimously.

The CHAIRMAN moved that Mr. John Bruce, of Edinburgh, be re-elected a director.

Mr. S. D. WILLIAMS seconded the motion, which was put and carried.

Mr. PUGH moved the re-election of Mr. W. A. Smith, of Glasgow, as a director, which was seconded by Mr. S. D. WILLIAMS, and carried.

Mr. BIGELOW moved the re-election of Mr. Jeremiah Garnett, of Manchester, which was seconded and carried.

On the motion of Mr. CARGILL, seconded by Mr. PUGH, the auditors, Messrs. Quilter, Ball, and Co., were re-elected.

On the motion of Mr. BIGELOW, seconded by Mr. NESS, a cordial vote of thanks was passed to the Chairman.

The CHAIRMAN said: I beg to thank you for the vote you have just passed. It will be the endeavour not only of myself as Chairman of the Company, but of all the Directors, to do all that is possible in the interest of the Company, and I have great satisfaction in saying that it is utterly impossible for the Chairman of any Company to be supported by a more energetic and intelligent Board of co-Directors, and I think, perhaps, it is somewhat of an omission that the vote should apply to the Chairman of the Company alone, and I would suggest that some shareholder in the meeting should move that it should be extended to the Directors of the Company. Our Directors, when they come to town, come from great distances. They have been elected and chosen for their position on the Board very much on account of their knowledge and influence in particular districts, and one and all of them give a great deal of attention to the interests of this Company in those districts. The prosperity of the Company is very largely increased by the intelligence and supervision they give to its interests in the various centres of the Company.

On the motion of a SHAREHOLDER the vote of thanks was extended to the Directors generally in accordance with the suggestion of the Chairman.

The proceedings then terminated.

An extraordinary general meeting of the National Telephone Company was held within the offices of the Company, 11, Queen Victoria-street, on Tuesday last, Colonel Raynsford Jackson presiding.

The SECRETARY (Mr. W. B. Campbell) having read the notice convening the meeting,

The CHAIRMAN said that having dealt so fully at last Friday's meeting with the subject for consideration to-day, it was not his intention to preface the proposing of the resolutions with any further observations. He would therefore at once move "That the capital of the Company be increased by the issue of 15,000 new shares of £10 each."

Mr. J. P. BIGELOW seconded the motion, which was carried unanimously.

The CHAIRMAN next moved, and Mr. J. S. HARRISON seconded, "That such shares be called Second Preference Shares, and that the holders thereof (subject to the payment of the preferential dividend on the original Preference Shares), be entitled to a cumulative preferential dividend at the rate of 6 per cent. per annum. After the Ordinary Shares have received a dividend at the rate of 6 per cent. per annum out of the profits of each year, the Second Preference Shares and the Ordinary Shares shall participate rateably, according to the amounts paid up thereon, in any surplus profits."

The motion was also agreed to *nem. con.*

On the motion of the CHAIRMAN, seconded by Mr. W. A. SMITH, it was also agreed "That the Second Preference Shares shall not confer any right of voting at any General Meeting of the Company, and in the event of the Company being wound up, the surplus assets thereof shall be applied, in the first place, in repaying to the holders of the original Preference Shares the full amount paid up thereon, and, subject thereto, in repaying to the holders of the Second Preference Shares the full amount paid up thereon in priority to any payment in respect of the Ordinary Shares of the Company."

This concluded the business.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. AUG. 12.		BUSINESS DONE WEEK ENDING AUG. 12. Highest.		Lowest.	
Anglo-American	29,	30	.....	30	.....	28¾ x d.
Do. Preferred	50,	51	.....	51	.....	49¾ x.d.
Do. Deferred	7½,	8½	.....	8½	.....	7¾
Brazilian Submarine	11,	11½	.....	11½	.....	11 1-16
Cuba	11¾,	12¼	.....	12½	.....	— x.d.
Do. Preference	17½,	18½	.....	—	.....	— x.d.
Direct Spanish	1½,	2	.....	—	.....	—
Do. Preference	12,	12½	.....	—	.....	—
Direct United States Cable	8¾,	9¼	.....	9	.....	— x.d.
Eastern Telegraph	11½,	11¾	.....	11¾	.....	11¼
Do. 6 per Cent. Preference	13,	13½	.....	13¾	.....	13
Do. 5 per Cent. Debentures, 1899	105,	108	.....	105½	.....	— x.d.
Eastern Extension	12¾,	13¼	.....	13	.....	12 13-16
German Union	9¼,	9¾	.....	9¾	.....	—
Globe Telegraph and Trust	7,	7½	.....	7½	.....	7 1-16 x.d.
Do. Preference	12¾,	13¼	.....	13	.....	12¾ x.d.
Great Northern	13¾,	14¼	.....	14¼	.....	14
Indo-European	30½,	31½	.....	31	.....	—
Reuter's	7½,	8	.....	—	.....	—
Submarine	—	—	.....	—	.....	—
West India and Panama	¾,	1	.....	—	.....	—
Do. 1st Preference	8½,	8¾	.....	—	.....	—
Western Brazilian	6⅞,	6⅞	.....	6½	.....	—
Western Union 7 per Cent. 1st Mortgage	120,	124	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	103,	105	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅛,	¼	.....	—	.....	—
Oriental	⅛,	¼	.....	—	.....	—
United Telephone	11½,	11¾	.....	11 9-16	.....	10¾

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	.....	—	.....	—
Do. (fully paid)	3½,	3¾	.....	—	.....	—
Hammond Light (£3 15s. paid)	⅛,	¼	.....	—	.....	—
Swan	⅛,	¼	.....	—	.....	—
Maxim-Weston	⅛,	¼	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	37,	38	.....	38	.....	37½
India Rubber, Gutta Percha, and Telegraph Works	24,	25	.....	24¾	.....	24¼

TRAFFIC RECEIPTS FOR JULY, 1885.

COMPANIES.	July, 1885.	July, 1884.	Increase.	Decrease.
Cuba Submarine	2,500	3,219	—	719
Direct Spanish Telegraph	1,260	1,501	—	241
Eastern Extension	46,099	40,870	5,229	—
Eastern Telegraph	48,081	50,072	—	1,991
Great Northern	25,200	—	—	—
West Coast of America	3,325	—	—	—

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NOTES.

AMERICA IN 1884.—During the year 1884 there were granted in the United States 1,074 patents for electrical inventions.

THE EARTHQUAKES.—A Reuter's telegram, dated Simla, August 14, says that shocks of earthquake are again being felt in Cashmere.

SUGGESTED.—A practical result of the recent visit of a scientific body to Lincoln would be the electric lighting of Lincoln Cathedral.

NEW ZEALAND.—It is believed that the old cable across Cook's Strait is broken. The cable had been down for 19 years, and had three wires.

TALL!—According to a Texas paper the corn stalks in that State are so tall and large that they are being used as telegraph poles by the Baltimore and Ohio Company.

AT THE OPERA IN PARIS.—The work of installing the electric light in the Theâtre de l'Opera, in Paris, is proceeding merrily. The inauguration is expected in October next.

THE ELECTRIC LIGHT AND ATHLETICS.—Eight electric arc lights have been placed in the Union Base Ball Park, St. Louis, U.S.A., to enable athletic sports to be carried on at night.

PROPOSED CENTRAL STATION AT DIJON.—It is proposed to establish a central electric lighting station to supply 500 lamps in the town of Dijon. The Edison Company have the matter in hand.

LONG DISTANCE TELEPHONY IN HUNGARY.—Satisfactory trials of long distance telephony have recently been carried out in Hungary between the towns of Csorna, Gallya, and Hereny, a distance of 110·36 miles.

THE TELEPHONE IN ROME.—The Italian Minister of Public Works has consented to the formation of the Società Romana Co-operativa dei Telefoni, thus uniting the two rival companies which have for some time existed in Rome.

HOSPITALITY.—The Town Council of Elgin have decided to entertain at the public expense 200 members of the British Association, shortly to assemble at Aberdeen, and to drive them to all the neighbouring places of interest.

THE ELECTRIC LIGHT FOR WAR SHIPS.—The largest of the new ships, the "Camperdown," barbette, is to be lighted throughout by electricity. The work, which will be carried out by Messrs. Siemens, assisted by the Dockyard staff, has been commenced.

THE TELEPHONE IN BELGIUM.—At 11 a.m. on the 9th proximo, at the Bourse de Commerce, Brussels, the contract will be let for the establishment and working of a telephone system in the town of Iseghem and its suburbs. The caution money is £400.

TELPHERAGE IN PHILADELPHIA.—The "telpherage" system is being experimented with in Philadelphia. Two cables are used, one above the other, the packages being suspended from the upper and steadied by the lower, and the cables serving as conductors.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th August are £2,141, as compared with £2,382 in the corresponding period of 1884. The April receipts, estimated at £7,790, realised £7,890.

THE EXPERIMENTS at CREIL.—The experiments at Creil will probably be concluded some time in the beginning of next month. The initial E.M.F. has, it is said, been reduced to 4,500 volts, but it yet remains to be seen if the insulation will resist so heavy a strain during ten consecutive hours per day.

LIGHTING THE GUILDHALL LIBRARY.—The Guildhall Library is shortly to undergo a thorough repair. Some dissatisfaction having been expressed at the present mode of lighting, hopes are felt that the City Lands Committee will consider the advisability of illuminating the library with the electric light.

MARRIAGE.—The *Morning Post* announces that a marriage has been arranged between Mr. D. Jardine-Jardine, only son of Mr. James Jardine, of Dryfeholm, Tinwald, and Torthorwald, Dumfriesshire, and Miss Mary Angela Bright, second daughter of Sir Charles Bright, of Bolton-gardens.

ELECTRIC LIGHTING IN THE NORTH OF ENGLAND.—The Edison Company, in addition to the Art Galleries mentioned in our last issue, are lighting the Manchester and Salford Bank, a large portion of Messrs. I. and T. Watts' Manchester warehouse, besides several gentlemen's houses, and other and smaller work in the same district.

ENTERPRISE IN AMERICA.—The Schuyler Electric Light Company, of Hartford, Conn., have obtained the contract for lighting the city of Richmond. The contract is for five years; and provides for lighting the city in such a manner as will make it one of the most brilliantly illuminated cities in the United States. That is saying a good deal.

THE TOMMASI RELAY.—This relay continues to give satisfaction in France. Trials which have recently been made of the relay between Paris and Toulouse, a distance of 483·6 miles, gave satisfactory results with 8 Callaud cells for the Morse instrument and 12 cells for the Hughes type-writer. The power used in ordinary working is, we are informed, about 125 cells.

NEW CABLES AND LAND LINES.—An American contemporary is informed that the Central and South American Telegraph Company has secured a commission to establish cables between Buenos Ayres and Rio de Janeiro, and land lines between Buenos Ayres and the Pacific side, thus securing continuous and independent telegraphic communication between the United States and Brazil.

ELECTRIC LIGHTING IN ITALY.—The municipality of Vazallo have recently decided to illuminate the town by electricity. The system to be adopted will be that of Cruto, and the streets will be lighted with 70 incandescent lamps. The current will be furnished by two dynamos driven by a turbine, as abundant water power is at hand in the torrent Sesia. Besides the public lamps, the dynamos will supply from 90 to 100 lamps in private houses.

NARROW ESCAPE OF THE EMPRESS OF AUSTRIA.—According to news received from Ischl, the Empress of Austria has had a somewhat narrow escape from what might have been a serious calamity. At five o'clock on the morning of the 13th, which is about the hour when the Empress takes her morning bath, her bath room was struck by lightning, the electric fluid knocking down Her Majesty's attendant, who was preparing the bath, and violently striking the parquet flooring.

A NEW APPLICATION OF THE INCANDESCENT LIGHT.—It is said that the incandescent light has been applied to the internal illumination of the telemeter by a committee of the German army. The lamp is placed in a recess normal to the main lunette of the telemeter, and between the eye and cross wires. The light of the lamp passes through a small hole in the wall of the lunette, and illuminates the cross wires. This

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illuminating of the wires is found to double the distance that the telemeter will measure.

A CONVENIENT ARRANGEMENT.—An American railway company has introduced a new and very accommodating feature on the limited trains. The guard on each of these trains is supplied with a large package of envelopes, each of which is weighted with lead, so that they may be tossed from a moving train to the station by passengers who wish to forward telegrams before the train reaches its next stopping place. On the envelope are printed directions for the telegraph clerk to forward the despatch at once.

EXTENSION OF AN ELECRIC RAILWAY.—The electric railway, which has been in operation since April, 1884, between Moedling and Brühl, in the suburbs of Vienna, is about to be extended to Hinterbrühl; its length will thus be increased from 3 to 4·5 kilometres. The system adopted is that of Messrs. Siemens, by which the current is produced at a fixed point and transmitted to the motors of the cars by metallic conductors along the route. The power is at present generated by five dynamos, each giving thirty amperes, with a difference of potential at the terminals of 500 volts.

AUSTRALIA AND CABLE RATES.—Intelligence from Victoria reports that the committee of the Melbourne Chamber of Commerce had decided to request the Postmaster-General to endeavour to get the Governments of the various colonies to co-operate with him in trying to induce the Eastern Extension Company to lower the rate charged for telegrams between Australia and New Zealand. They had also decided to seek the co-operation of the Chambers of Commerce in New South Wales, S. Australia, New Zealand, and other colonies in urging the respective Governments to take action in the matter.

A ROYAL TRIP.—The Princess of Wales, and the Princesses Louise, Victoria, and Maud left Charing-cross on Wednesday evening by special train *en route* for Gmunden, the seat of the Duke of Cumberland, in Upper Austria. At Dover the royal party were met by Major-General Hon. P. Feilding, C.B., commanding the South Eastern District; Colonel Sir Cromer Ashburnham, K.C.B.; and the other members of the general's staff, by whom they were escorted on board the "Invicta," Captain Dane. The landing stage and the approaches were thronged with spectators, and were illuminated by electricity from the steamer.

IRON TELEGRAPH POLES.—Iron telegraph posts have been introduced with great success in Switzerland, and are now being extended daily. They have been already put up on Swiss railways a distance of 350 miles. In Prussia they have been placed experimentally on the railway from Weissenfels to Gera, and on the line between Berlin and Potsdam. As iron is now so cheap, it is considered that in a short time they will altogether replace the old wooden poles in Germany, that cause so frequent interruptions to telegraphic communication from rotting or being blown down by every high wind, especially in exposed situations.

THE TELEGRAPH IN SOUTH AMERICA.—The American Telegraph Company have opened telegraphic communication between Chillan, Talcahuano, Concepcion, Coronel, and Lota, and it is expected that the line in course of construction between Chillan and Talca will be completed by the end of the present month, which will place the port of Valparaiso in direct communication with the southern part of the Republic. A telegraph line is to be erected between Arica, in Peru, and Lapaz, the capital of Bolivia, the tariff to be two Bolivian pesos per word. The line is to be completed within six months. The Peruvian telegraph line is now in operation to Casma.

STRONG STATEMENTS.—Suit has been entered in the United States Court at Memphis on the 10th inst., by the Pan Electric Telephone Company against the American Bell Telephone Company. The bill filed charges that the Bell Company's patents interfere with the Pan Electric patents, and are, to that extent void; that the Bell Company has slandered and misrepresented the patents and inventions of its opponents; that the Bell telephone in use is not the one described in its original patent, which is used only to litigate with; that Bell was not the first and original inventor of the art, it being known to and described by Phillipp Reis, of Germany, who died in 1874.

THE ELECTRIC TRAMWAY AT BLACKPOOL.—Recently a special meeting of the directors of the Blackpool Electric Tramway Company was held, to take into consideration the general affairs of the company. Afterwards, Mr. M. Holroyd Smith, the engineer, ran two cars, crowded with people, to and from the shed to the promenade, an itinerant brass band playing on one of the cars. The smoothness in running and the facility with which the cars were started and stopped were admired, and the experiment showed that the cause which prevented the line being passed by the Government Inspector did not lie with the company. It is expected the line will be ready in about three or four weeks. Up to now, over 21,000 persons have ridden upon the car.

THE TELEPHONE IN TONQUIN.—The telephone system in Tonquin, extending from its centre at Hanoi, has already reached a development of about 160 miles. The main lines are three in number. The first of these is from Hanoi to Haiphong, following the course of the Red River and the Bambous Canal. This line, which is in connection with two submarine cables—one to Saigon, and the other to Hong Kong—was finished at the end of 1883. The second is from Hanoi to Hong-Hoa, by way of Son-Tay (37·2 miles); while the third is from Hanoi to Phu-Lang-Thuong, a distance of 28 miles. Phu-Lang-Thuong will serve as a junction for the two lines now in course of construction, one going to Kep, and the other to Chu. The number of messages circulated upon the three lines amounted during the first eleven months of 1884 to 151,000.

AN ENTERPRISING SCHEME.—It is said that a number of telegraph operators of St. Paul, Minn., have incorporated the Operators' Telegraph Company, with a capital stock of $10,000,000. It is intended by those who have the project in hand to extend the wires of the new company all over the country, and to compete with the Western Union Telegraph Company. The design is to make the company co-operative, and it is intended to enlist all the operators in the United States in the enterprise. It is claimed that stock to the amount of $100,000 has already been taken, and the work of construction will be at once begun as soon as $500,000 worth of stock has been subscribed for. The first line built will be from St. Paul to Chicago. It is thought that the requisite amount can be secured in six months' time, and that by spring the work will be prosecuted with vigour.

SCIENCE AND ART DEPARTMENT, SOUTH KENSINGTON.—The list of successful candidates for Royal Exhibitions, National Scholarships, and Free Studentships, May, 1885, is as follows:—National Scholarships: William Burton, Manchester; Philip L. Gray, Southampton; Charles Lang, Johnstone, N.B.; Thomas Clarkson, Pendleton, Manchester; William Kelsall, Bradford; Henry Sowerbutts, Manchester; Frederick Chattaway, Birmingham; William Scudamore, Northampton; Frederic W. Lanchester, Southampton; Thomas H. Holland, Helston; Harold E. Hey, Man-

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chester ; William Blackmore, Sheffield. Royal Exhibitions: Harry E. Hadley, Worcester; Hugh O. Bennie, Glasgow ; James Young, Belfast ; Arthur J. Moulton, Preston ; Harold C. Coote, London ; Robert H. Unsworth, Pendleton, Manchester; Sidney H. Woolhouse, Weaste, Manchester. Free Studentships: David Wilkinson, Preston ; Henry P. Motteram, Small Heath, Birmingham ; Albert E. Briscoe, Birmingham ; Orlando J. Preston, Bristol ; James M'Kenzie, Glasgow ; Philip C. Coultas, Bristol.

POST OFFICE VOLUNTEERS.—The men of the 24th Middlesex, Post Office Volunteers, numbering 450 strong, returned to town on Saturday last, after a week's camping out and drill at Aldershot, under the command of Lieut.-Colonel du Plat Taylor. The weather during the greater part of the week was fine and warm, and although, as usual, there were some cases of sickness among them, the men on the whole return improved in health and vigour. On Friday the members of the Telegraph Signalling Corps were examined in flag-signalling by the Signalling Officer of the Wiltshire Regiment, the result of which has not yet been announced. Some of the telegraphists of the Reserve force who went out to Suakim with the last contingent have now returned to England, but are still encamped at Aldershot, probably with the view of recruiting their health before being discharged. But it was with much surprise and some indignation that the Post Office Volunteers found that their comrades, several of whom were invalided, had been placed at Borley Bottom in charge of a number of sick horses, suspected of being infected with glanders. This treatment of our volunteers after the hardships of the Suakim expedition is felt to be unfair, as well as impolitic.

SUCH IS LIFE!—The death lately occurred at San Francisco, in a state of destitution, of Johnny Skae, who some few years ago was estimated to be worth ten millions of dollars. He was employed at Virginia city as an operator in the California Telegraph Company when the four Bonanza kings—Flood, O'Brien, Mackay, and Fair—were developing their operations connected with the silver mines in California and Virginia city. They communicated with each other in cipher. Skae discovered the key to this cipher, and became aware long in advance of every one else of the marvels which were to astonish the public. All the money he could command or borrow he invested in shares of the two mines; and when the allotment was finally settled, and public excitement had somewhat cooled, it was found that the telegraph operator was worth $3,000,000. But he was not content, and speculated largely in much less safe investments, so that when the commercial crash came soon afterwards it quite ruined him. He disappeared from view altogether until about a year ago, when a policeman in San Francisco found him lying on the street at night hopelessly drunk. The man who some years before was worth ten millions of dollars, upon being searched was found to possess only a few small coins.

AN IMPORTANT ACTION.—Judgment was entered on July 24, in the United States Superior Court, against the Western Union Telegraph Company and in favour of James H. Goodsell, for $240,159.11. In appears in January, 1881, Mr. Goodsell, as president of the National Associated Press, made a contract with the Atlantic and Pacific Telegraph Company for the dissemination of news. The contract came into effect on Feb. 1, 1881, but on Feb. 3 the Atlantic and Pacific Company fell into the hands of the Western Union Company, which assumed to carry out its contracts. The Western Union Company in 1882 charged Mr. Goodsell greater rates, and stopped the service because he refused to pay them. In July, 1882, Mr. Goodsell brought suit against the Western Union Company to recover $22,000, which, he alleged, the company had collected from different newspapers for his service, and had failed to account to him for. He also asked for damages to the extent of $650,000 for a breach of contract. The Western Union Company alleged that the contract was invalid and fraudulent, and that a new arrangement had been made and carried out, but that finally Mr. Goodsell abandoned the work. For this they put in a counter claim for $15,000 damages. Of the judgment entered $220,306 is for damages and $16,777.42 for money due, the rest being interest.

THE ELECTRIC LIGHT IN BRAZIL.—A Brazilian daily paper, in commenting upon an installation recently put down in Para, says:—"Due to the perseverance and efforts of Mr. Carlos Monteiro e Souza, we witnessed a trial or exhibition of the apparatus which took place both at Merces-square and at the large commercial house of Messrs. S. Aguiar and Co. When the machinery was set in motion at the first of these places, the square was instantaneously flooded with light as brilliant and soft as the tropical full moon on a cloudless night. At the same instant the same effect was produced in the establishment of Messrs. S. Aguiar and Co., on the Rua da Imperatriz. The machinery is set up in a building, 32 × 13ft. A vertical (six horse-power) steam engine is used to run the dynamo. This little machine, which weighs only 600 pounds, has a pulley eight inches in diameter, which makes 1,400 revolutions per minute, while the drive wheel of the engine makes 245. The lamps and dynamo are of the Thomson-Houston system, the property of a large and enterprising company of Boston. The machinery was set up by the excellent machinist, Henrique Paiva, proprietor of the extensive shops on Merces-square. Mr. Carlos Monteiro e Souza, now an enthusiastic apostle of electric lighting, is forming a stock company in Para to furnish arc and incandescent light in the provinces of Para and Amazonas. It is said that he is soon to return to the United States to contract for the apparatus needed by the company."

THE NEW YORK UNDERGROUND WIRE COMMISSION.—The commission appointed to compel the telegraph, telephone, and electric light companies to take down their poles and place their wires under ground, in New York, held its first meeting for organisation at the Metropolitan Hotel, on 26th July. President Loew offered a long preamble and resolution, declaring that under the law it was the duty of the commission to cause all telegraphic, telephonic, and electric light wires to be put under ground, and that the commission proposed to do the work for which it was appointed as speedily as possible. The law requires that plans and maps, with estimates of cost, shall be filed by the companies with the Board within 60 days after its passage, or before 14th August, and if they do not do this the commission is authorised to adopt a plan of its own. It is the purpose of this Board, the preamble says, to cause the wires to be placed under ground, and the secretary is instructed to notify all persons or companies owning or controlling the wires above ground, that the Board will receive at the Metropolitan Hotel any plans, maps, or methods proposed for its approval, and that it requests that such plans be submitted as soon as practicable before the expiration of the 60 days prescribed in the law. The resolution was passed. The following, proposed by Mr. Hess, was also adopted:—"Resolved, that the owners, lessees, or occupants of houses be requested to refuse permission for the placing of any telegraphic, telephonic, or electric wires over or on their respective buildings, without first securing a permit

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from this Board." Another resolution offered by Mr. Hess, requesting the companies to offer to the Board at its next meeting any plans which they may have for placing new wires above ground, was passed, and the commission adjourned.

OBITUARY.—The death is announced at Perth, Western Australia, of Mr. FLEMING, Superintendent of Telegraphs. We regret to have to announce also the death, at Santa Cruz, Teneriffe, on the 22nd of July last, of Mr. R. BALKWILL, of the Silvertown Company's submarine cable engineering staff. Mr. Balkwill had been in the Canary Islands since the end of 1883, and subsequent to that date had done a considerable amount of work in connection with the system of the Spanish National Submarine Telegraph Company; these operations included the putting down of underground land lines to connect the shore ends of the cables with the offices at Santa Cruz, Teneriffe; Las Palmas, Grand Canary; and Arrecife, Lanzarote; also the construction of stone cable houses in Lanzarote and Teneriffe, and various operations of lesser importance. Mr. Balkwill accompanied the expedition from the India Rubber Company's Works which laid the cables of the West Coast of South America Company, extending from Lima to Valparaiso, and also the later expedition which laid those of the Central and South American Telegraph Company, connecting Lima with the Isthmus of Tehuantepec in Mexico. He also has laid at different times various lengths of underground cable in connection with the Direct Spanish Telegraph Company's system, both at Falmouth and at Bilbao. Mr. Balkwill, who died of typhoid fever after an illness of only twenty-six days, at the age of thirty-eight, is deeply regretted by all who had the pleasure of knowing him. The death is also announced at Castellon de la Plana, Spain, from cholera, of Don NICHOLAS GIL DOBZ, a member of the Spanish Government Telegraphs. He was for some time stationed at the Las Palmas office of the Spanish National Submarine Telegraph Company, and was very popular with his English companions.

PROPOSED ELECTRIC LIGHTING AT NEWCASTLE. — At a recent meeting of the Newcastle City Council Alderman Newton moved the sealing of a memorial to the Lords of the Treasury, asking for sanction to increase the power to borrow money in respect of the Public Library from £22,000 to £25,000. He said £1,800 of the extra £3,000 for which they wanted borrowing powers was for the final completion of the library, and £1,200 was for the lighting of the library with the electric light. They did not propose to adopt the electric light at once, but desired to make provision so that in the event of its being deemed desirable at some future time to adopt electricity they would be able to do so without having to make another application to the Lords of the Treasury. If they could get the electric light at the same price as the gas, it would be a great saving to the Corporation, inasmuch as the gas was very prejudicial to the bookbinding, whereas the electric light was not so. However, his motion did not commit them to the adoption of the electric light. That would not be done without the special vote of the Council.—Mr. W. Smith seconded the motion.—Alderman Barkas moved that that portion of the memorial which referred to the £1,200 for electric lighting should be struck out. The electric light would be much more expensive than the lighting by gas. The latter cost at present £114 per annum. The electric light would cost about £370. Mr. Goolden seconded the amendment. After some discussion a vote was taken. On the amendment 17 voted for and 17 against; it was therefore not carried. The original motion was then put, and it was negatived by 20 to 16. It was agreed, however, that the memorial, so far as related to the £1,800 for general purposes, should be sealed, the opposition being entirely concentrated on the £1,200 for electric lighting.

SOME NEW EXPERIMENTS.—An observation of M. Felix Lucas upon the radiation of incandescent carbon has recently been communicated to the Academie des Sciences. The author begins by recounting how with inoxidisable metals heated in air the radiations, at first obscure, become more and more luminous as the temperature is raised. Thus, according to M. Pouillet, a temperature of 525° C. corresponds to a just visible red; and that of 1,500° C. to brilliant white. An analogous phenomenon is observed if carbon is heated, being previously placed in a vacuum to prevent combustion. When sufficiently heated, the carbon becomes a veritable lamp, thus showing the existence of a relationship between the temperature and the brightness of the radiations from the body. With a view to determine this relationship in precise terms, M. Lucas prepared an arrangement of apparatus whereby he could heat in vacuo (by the current from a De Meritens machine) some specimens of ordinary arc lamp carbon, 5 mm. in diameter, manufactured by M. Carré. He obtained formulæ by which he was able to calculate the temperature of the carbon corresponding to any observed intensity of current and illuminating value. By this means he was able to trace how the illuminating power increased with the heat from the first visible glow at 1,000° C., valued at only 3 carcels, rapidly up to over 300 carcels, and then slower, until at a temperature of 4,500° C., the luminous radiations were equal to 413 carcels. Up to this point, therefore, although the heat had been only increased in the ratio 1:4·5, the luminous intensity was increased in the ratio 3:413. Now, however, a curious phenomenon appeared. An increase of temperature from 4,500° to 4,750° C. only increased the light from 413 to 420 carcels; and a further increase of temperature to 5,000° C. actually had the effect of lowering the light to 413 carcels, or the same intensity as that produced at a temperature 500° lower. It is noteworthy, as contrasted with this, that the increase of temperature from 3,125° to 3,520°, or only 395°, doubled the light emitted from the carbon. Thus, after a certain point, increase of temperature has a lessened effect in developing light, until, beyond the maximum of 4,750°, heat ceases to provoke more luminous radiations, and even reduces their visual value. Consequently, in stating this most striking conclusion, M. Lucas expresses the opinion that it is probable that calorific radiations, at first obscure, then successively luminous from red up to white, finish by passing beyond the violet end of the spectrum, and thus cease to be visible. Heat may therefore be invisible because of its intensity as because of its feebleness.

A VOLTAIC CELL WITH A SOLID ELECTROLYTE.—"I believe that there has never hitherto been made a voltaic cell with a solid electrolyte which was capable of generating the smallest sensible current—at least at ordinary temperatures. Sir William Thomson found that when warm glass was placed between plates of zinc and copper, the existence of an electromotive force was indicated by an electrometer in connection with the metals, and Profs. Ayrton and Perry extended the observation to the cases of paraffin wax, gutta percha, india rubber, and shellac. But it is needless to say that with electrolytes of such enormous resistance no current could be generated of sufficient strength to be detected by any galvanometer, however delicate. On June 27 I exhibited to the Physical Society a little cell consisting of plates of silver and copper, between which was contained a mixture of one part of copper

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sulphide with five of sulphur. When this cell was connected with a reflecting galvanometer it produced a current by which the spot of light was at once deflected off the scale, copper being the positive pole. The electromotive force was found to be ·07 volt, and the internal resistance 6,537 ohms. The current, therefore, though far more than merely sensible, was small. Attempts were made to reduce the internal resistance by diminishing the proportion of sulphur contained in the mixture, but it appeared that as the sulphur was diminished the electromotive force was also diminished, until, when there was no free sulphur at all, the cell failed to produce the smallest measurable current. It occurred to me that the sulphur owed its efficacy to the fact that it formed a film of silver plate by direct combination. I therefore made a cell thus :—A thin layer of copper sulphide was spread upon a copper plate and compressed into a compact mass against a surface of polished steel. A layer of silver sulphide was then spread upon the copper sulphide, and the cell was completed by pressing a silver plate upon the silver sulphide. The current which this cell produced through the shunted galvanometer was considerably stronger than that generated by the cell first described; but still the result was not quite satisfactory, and there seemed to be indications of short circuiting, which I thought might possibly be due to the penetration of particles of copper sulphide through the layer of silver sulphide. The silver plate was therefore removed from the cell, and having been brushed over with a weak solution of sulphur in bisulphide of carbon, it was heated over a gas flame, and soon became covered with a uniform and continuous coating of sulphide. The heating was continued until all the free sulphur was evaporated. When the cell was reconstructed with this prepared plate it produced a current of 6,800 micro-amperes through an external resistance of ·2 ohm, and was able to deflect the pivoted needle of an ordinary coarse galvanometer. The dimensions of the cell are as follow :—The copper and silver plates measure 2½in. by 2in.; the thickness of the two layers of sulphide (strongly compressed) is about 1-20in.; the E.M.F. is ·053 volt, and the internal resistance is therefore about 7 ohms. This cell seems to be exactly analogous in its action to a Daniell cell in which plates of copper and zinc are immersed in solutions of copper sulphate and zinc sulphate. Silver is probably the best (or only) possible metal for the positive plate, but some other metal might perhaps be substituted for the copper with advantage."—Shelford Bidwell, in *Nature*.

ELECTRICITY AND THE NAVY.—Speaking of the recent inspection by the Lords of the Admiralty, *The Times* says :—"It only remains to state, by way of conclusion, that remarkable progress has been made during the past twelve months in the general adoption of electric light apparatus in nearly all sorts and conditions of men-of-war, so far as search lights are concerned, though only a limited number are as yet fitted. The machines selected are also suitable for the internal lighting of the ships by the incandescent system, and there can be little doubt that the superior comfort and even the necessity of electric lighting will be soon universally recognised in a practical manner. There have been complete installations on board the Indian and other troopships, the torpedo ram, "Polyphemus," and the "Colossus," and there are to be similar installations in the "Collingwood," "Edinburgh," and "Impérieuse." At the beginning of the year a carefully conducted trial of a week's duration of the "compound wound" dynamos, known as the Victoria, was carried out in the "Colossus," which fully demonstrated that electric lighting on board ship, in addition to many other advantages over oil and candles, also possesses in a striking degree that of economy. These experiments, which were continued uninterruptedly day and night, were based on the actual requirements of a ship at sea, and doubtless hastened the decision to fit dynamos in all our fighting vessels. The cost of systematic trials of this kind has to be borne by the Admiralty. But the trials have already borne good fruit for the navy and country generally, and will amply repay the nation in the long run by reducing the expense of the lighting apparatus and the expenditure of fuel. It is also worth alluding to the other numerous and important electric appliances which have found a home on board our vessels of war. The ships are navigated from armoured towers or other protected positions, where are placed every requisite for fighting or navigating purposes. The commanding officer must be able to communicate readily by voice pipes with the battery or turrets, with the engine rooms, magazines, and various other parts of the ship. But it has been thought expedient in some ships to supplement the ordinary means of communication by telephones, and different systems are under trial. The experiments must, however, extend over a considerable period and under different conditions before it can be absolutely decided which is the best method to adopt, or whether, indeed, telephones can be relied upon in such ships in cases of emergency. But it is also necessary that the officer shall not only be in a position to convey his orders from the tower to the engine room and fighting stations, but that he shall also be certain that his instructions are understood and obeyed. This is accomplished by a system of electric telegraphs and revolution indicators. Electric steering telegraphs and tiller indicators are also necessary parts of a perfect equipment, and in order to enable the commanding officer to have complete control of the guns and torpedoes, so that he may be able to discharge all or any of them as required, electric firing currents are fitted, by means of which he has only to press a key, and so complete the circuit, to fire the guns or eject the torpedoes at will. In turret ships it is, furthermore, important that the guns should not be fired when directed, as they must be while the turret is being rotated, towards any part of the superstructure, or when they are depressed in some positions towards the deck. To prevent accidents arising from the non-observance in the heat of action of the precautions against accidents automatic electrical arrangements have been devised, by which it is simply impossible for the guns to be fired when at the 'dead points.' Additional electric combinations are necessary to enable the guns to be fired from the turrets instead of from the conning tower. These tend to further complicate matters on board, and without enumerating in detail other costly electric fittings of a man-of-war, we have only to add that auxiliary conning stations are provided in case of disaster occurring to the main positions, to show how absurd and misleading it is to compare, as is sometimes done, the cost of constructing an armoured with that of a merchant ship." One of the points still under consideration as regards the "Inflexible," previously visited, is the expediency of completely lighting her by electricity. Their lordships' experiences on board the "Colossus" must have removed any vestige of hesitation on their part as to the transcendent superiority of the latest system of illumination, as the "Colossus" is actually ready for sea with the exception of the trial of her guns. When, on their lordships going on board, the whole of the interior spaces were lighted by incandescent lamps the effect was so extremely brilliant that the visitors could not refrain from expressing their satisfaction. Among the estimates of the various departments of the Admiralty the following items appear :—For extension of electric shop, £700; lightning conductors, £900.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 231.)

Simultaneous Conduction Current and Elastic Displacement.

In the ordinary intercourse of Man with his environment he is more or less accustomed to overlook, ignore, or treat as non-existent all phenomena whose recognition is not of immediate practical utility to him. (Plato, on the Celestial Harmony.) For instance, very few people are even aware, until their attention is forcibly called to it, of the multitude of most singular optical phenomena that occur in the everyday use of the eyes, some of them very difficult of explanation. Their perception would not be of immediate utility to the average man. They are therefore left unnoticed, as if they were not, until even recognition of them becomes difficult. The phenomena occur, and are seen by the eye mechanically, but the mind's eye is blind to them.

Most electricians, in a somewhat similar manner, are accustomed to confine their attention to only one part of the wonderful phenomena occurring during the existence of a conduction current. They may think of the wire, of its resistance, the current in it, and the E.M.F. causing it. Or possibly, in a more advanced stage, they may think also of the heating of the wire, and of external work done, as in driving a motor, with the necessary consideration of conservation of energy as regards the amount of work done. Still, however, it is the current in the wire that is the first object of attention, and what goes on outside it is ignored. This is perfectly natural, for what we call the strength of the current is the one thing that is, in the steady state, practically altogether independent of the external conditions; whilst again the steady state is of great importance, and may be brought under calculation with comparative ease. We are aware of the existence of an external magnetic field, and also of an electric field, or of an electro-magnetic field having two sides, the electric and the magnetic. They vary under different external circumstances, but as the steady conduction current is independent of them they are ignored. This independence, which is really a fact of an extraordinary character, is, by habit, taken for granted, and ceases to have anything remarkable about it.

If we have a closed circuit with a steady impressed force in it, there results a steady current in the circuit, whose strength is calculated from the data relating to the wire itself, and is independent of the distribution of matter around, provided we do not disturb the insulation at the immediate surface of the conductor. If we bring a mass of iron near the circuit, or in general alter the distribution of external matter as regards its permeability to magnetic induction, there results merely a momentary disturbance of the conduction current. When this has ceased, the current is just as it was before, although the external state has been considerably altered, there being in particular a different magnetic field, and a change in the distribution of the rays of energy converging to the wire. This, with the similar transient disturbance of current by motion of a magnet or another closed current, comprises what is ordinarily understood by the induction of currents. Only the magnetic energy is concerned, in the main.

There are also the inductive effects due to alterations, not of the magnetic permeability, but of the electric capacity outside the wire, or by altering the external electric field. The current induced, or the alteration made in the previously steady current, is, as in the case of magnetic induction, transient only, and no disturbance is produced finally in the distribution of current. (Except indirectly, as by altering the structure of the wire itself, and its conductivity.)

The effect of surrounding a wire supporting a current with soft iron is to decrease the current temporarily. On the other hand, the effect of surrounding it with gutta percha is to increase the current on the whole temporarily, it being increased in that part of the circuit next the source more than it is decreased in the other part. If in the former case T be the increase made in the magnetic energy, the battery does 2T less work than if the iron had not been brought to the wire. In the latter case, if U be the increase made in the electric energy, the battery does 2U more work than if the gutta percha had not been brought to the wire.

Both the inductions, electrostatic and magnetic, are in simultaneous action always. In a large class of cases, however, especially with condensers, the magnetic induction is of comparative insignificance. In another large class, as of coils containing iron, and circuits closed, the electrostatic induction is negligible. In intermediate cases, when neither is negligible, we have very complex effects. But in all cases there is no permanent effect on the distribution of conduction current, however greatly the electric and magnetic fields outside the circuit are permanently altered, and likewise the manner of transit of energy from the source to the parts of the circuit away from the source. In brief, when the impressed forces are given, the conductivity conditions alone determine the steady state of the current. And, although it is not at once seen, the same is true whatever electric capacity (or permeability) the conductor itself may possess, so that there is interior electric (or magnetic) energy. The latter is recognised. Also, the electric capacity of very bad conductors is known. But there is little or no information regarding the capacity of good conductors, though, for various reasons, I believe in its existence. The coefficient of permeability μ is known to never vanish. That of conductivity k has an enormous range, and may perhaps also vanish altogether—for instance in planetary space, if nowhere else. Similarly, the coefficient of electric capacity c may have a larger range than it is at present supposed to have in bad conductors. We tacitly assume $c=0$ in good conductors in general.

It will be understood that in thus speaking of the electric capacity (specific) of a conductor, we do not in any way refer to the Capacity of a Conductor of electrostatics, which is really the capacity of the surrounding dielectric, by all analogy with usage in the corresponding conduction problems. We refer to the specific capacity of the material of the conductor for elastic displacement in itself. This has, of course, nothing to do with the nonconducting dielectric outside. It is sometimes said that the specific capacity of a conductor is infinite. This is a mischievous delusion. It is tolerable, for mere mathematical purposes, sometimes to assume $c=\infty$ in a conductor, and ignore its conductivity altogether; *i.e.*, do away with the conductor, and substitute for it a dielectric of infinitely great specific capacity. We may, similarly, sometimes conveniently replace a voltaic cell (mathematically) by a condenser of infinite capacity and constant difference of potential. Or, we may consider a modern accumulator as a condenser for limited purposes, in spite of the obvious radical difference in their physical nature. But the absurdity of considering a conductor as of infinite specific capacity is readily seen. For although we may, by increasing greatly the specific capacity of a dielectric, imitate, in some respects only, a conductor, yet as specific capacity refers to elastic displacement, such displacement must afterwards subside when allowed to, which is wholly different from the behaviour of conductive displacement, which has no tendency to return. The proper condition is not $c=\infty$, but $c=0$ (unless we know there is elastic displacement in the conductor, as we do when it is badly conducting), with the auxiliary condition, k finite. Conductive and elastic displacement are wholly distinct things, and may be combined in any proportions. The former dissipates energy, the latter stores it.

In the following is an investigation of the general problem of steady impressed electric force and electrification in space with any distributions of electric capacity and conductivity. So far as I know, it has not hitherto been fully treated, but only piecemeal, and under limitations. For instance, Maxwell's treatise does not consider impressed force in the dielectric at all, and the capacity of conductors but imperfectly. Nor, again, is the determination of the state of the dielectric due to currents in conductors treated, which presents some curious peculiarities. Also, it is of advantage to deal comprehensively with the matter, since in practice we really have this simultaneous conduction and elastic displacement, either at the same or at different places, but connected. Being too long for one section, the following will continue it.

Given k and c the electric conductivity and capacity for

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conduction current C and elastic displacement D at every point of space, and also the distribution of impressed force e; find the steady state, or, rather, show how it is determinate. E being the electric force, we have

$$C = kE, \quad \text{div.}C = 0, \quad \text{curl}(e - E) = 0, \quad . \quad . \quad (86)$$
$$D = cE/4\pi, \quad \text{div.}D = \rho, \quad \text{curl}(e - E) = 0, \quad . \quad . \quad (87)$$

for the full statement of conditions at a point. First, the linear relations, viz., Ohm's law and Faraday's (or Thomson's or Maxwell's). The second of (86) expresses that the conduction current is continuous everywhere, and the second of (87) defines the electrification density ρ in terms of the displacement, viz., its divergence, the proper measure of the discontinuity of the elastic displacement. The third conditions are identical. They express that the actual force E is the sum of impressed e and of a polar force F, such that curl F = 0. If $c = 0$ at a certain place we have only (86) to consider; if $k = 0$ then only (87); if neither vanishes, then both. Also, there will usually be surface conditions, which will come later.

First imagine $c = 0$ everywhere, and k finite everywhere, that is, an infinite conductor whose conductivity nowhere quite vanishes, and of no capacity. Then we may write either

$$\text{div.}k(e + F) = 0, \quad \text{curl}F = 0, \quad . \quad . \quad . \quad . \quad (88)$$

and determine F; or else

$$\text{div.}C = 0, \quad \text{curl}(C/k - e) = 0, \quad . \quad . \quad (89)$$

and determine C. It is obvious that the first of (88) has any number of solutions for F; we must then show that one (and only one) of them satisfies the second of (88), thus fixing F. Or, it is obvious that the second of (89) has any number of solutions for C; we must then show that one (and only one) of them satisfies the first of (89) thus fixing C. Thus, since the first of (88) expresses that C is closed, choosing any closed C settles F. Or,

$$kF = \text{curl}\,A - ke$$

is the general solution, wherein A is any vector whatever. Similarly the general solution of the second of (89) is

$$C/k = e - \nabla P$$

wherein P is a perfectly arbitrary scalar.

Now, whatever F and f may be, if $F_1 = F + f$

$$\Sigma F_1 k F_1 = \Sigma(F + f)k(F + f) = \Sigma FkF + \Sigma fkf + 2\Sigma Fkf$$

the Σ indicating summation through all space. But if F satisfies both of (88) whilst f satisfies only the first, the third summation on the right vanishes. For F is polar, and kf is closed, so that, by the elementary property of the polar force, $\Sigma Fkf = 0$ for any one infinitely small tube of kf, and therefore for all. Thus we are reduced to the first and second summations on the right side. The first is fixed, the second may vary, but is necessarily positive, every element of it being positive. Hence $f = 0$ makes the summation $\Sigma F_1 k F_1$ a minimum. But F_1 is any solution of the first of (88), whilst F is a solution of both, so we prove that any solution F_1 of the first which also satisfies the second of (88) makes $\Sigma F_1 k F_1$ a minimum. But this quantity has a minimum, for it is necessarily positive unless $F_1 = 0$ everywhere. Hence there is a solution of (88), viz., F, when $f = 0$. There cannot be two solutions. For, if F and F + f be both solutions of (88), we must have curl$f = 0$ and div.$kf = 0$, and therefore $\Sigma fkf = 0$, which can only be by $f = 0$, making F the sole solution.

We may treat (89) similarly. Let C satisfy both conditions, whilst C + γ satisfies only the second, so that γ satisfies curl$\gamma/k = 0$. Then the total Joule heat per second is

$$\Sigma(C + \gamma)k^{-1}(C + \gamma) = \Sigma Ck^{-1}C + \Sigma\gamma k^{-1}\gamma + 2\Sigma Ck^{-1}\gamma.$$

Here the third summation on the right vanishes, because C is closed and γ/k polar. The second summation is necessarily positive, therefore $\gamma = 0$ makes the heat a minimum. This closes the current, making C + γ become C, satisfying both conditions. As the minimum is necessary, the necessity of a solution of (89) follows, and that it is unique is shown by $\Sigma\gamma k^{-1}\gamma$ vanishing when γ is closed and $k^{-1}\gamma$ polar, requiring that $\gamma = 0$, if we assume that C and C + γ are both solutions of (89)

As regards (88), we may state the result thus. There is one distribution of polar force F, a linear function of which, namely, kF, has a given distribution of convergence, conv.kF = div.ke. Or there is one distribution of force E differing from e by a polar force alone, a linear function of which, namely, kE or C, is continuous everywhere. As regards (89), we may similarly state that there is only one closed current C, a linear function of which, namely, C/k or E, has a given distribution of curl, viz., curl C/k = curl e.

Or, assuming that Ohm's law and the continuity of the current are always obeyed, let C vary. Then $\Sigma Fk F$ is made a minimum by that one distribution of C which makes F polar. And, assuming that Ohm's law is obeyed, and also that F is always polar, let F vary. Then ΣEC, the heat, is made a minimum by that one distribution of the current that is completely closed.

The gist of the above, and also of the more abstruse and complex demonstrations that may be given, is expressed by the theorem $\Sigma FC = 0$, or, a polar force, F, does no work on a closed flux, C, arising from the property of a polar force that its total round any closed curve is zero. Given first Ohm's law, the linear connection between the actual electric force and the current density, and also that the current must be closed. If the impressed force be so distributed that it alone is sufficient to satisfy Ohm's law and continuity (that is, when div. $ke = 0$), the force e is the actual force and the current is ke. But should this condition not be complied with by the impressed forces it is clear that an auxiliary or complementary force, F, is required which, together with e, shall make up the actual force E to satisfy continuity and Ohm's law. The question, then, is, how is this complementary force to be found? Any number of F's may be made up, but only one of them is completely polar. We then have $\Sigma FC = 0$, and the total heat expressed by

$$\Sigma EC = \Sigma eC = \Sigma eke - \Sigma Fk F.$$

It is naturally suggested by this making of the total heat equal to the activity of the impressed forces, that we examine the effect of subjecting the complementary force, not to being polar, but to satisfying $\Sigma FC = 0$, or $\Sigma eC = \Sigma EC$, which is possible in other ways than by a polar force. Thus, knowing that F uniquely determined polar satisfies this condition, and supposing that E, C, and F represent the real solution, let us alter the current in any manner, keeping it closed, also obeying Ohm's law, and finally keeping the heat per second always equal to the activity of the impressed forces. Let f be the alteration in the complementary force, then kf is the alteration in the current, and is closed. Also the alteration of ΣeC is Σekf. But, by our final restriction above,

$$\Sigma(F + f)(C + kf) = 0, \text{ or } \Sigma f(C + kf) = 0,$$

which reduces to

$$\Sigma ekf = -\Sigma fkf$$

on putting $C = k(e + F)$, and then $\Sigma Fkf = 0$, F being polar and kf closed. But Σfkf is positive, hence Σekf is negative. Hence ΣeC is reduced. That is to say, any change made in C from the real current, subject to Ohm's law, continuity and conservation, decreases the heat and the (equal) activity of the impressed forces. Hence, in the real case, the impressed forces work as fast as ever they can, and this is by having the auxiliary force polar.

Taking a simple linear circuit, to exemplify, we find that there are only two solutions, the real, and C = 0. Both satisfy conservation (meaning $\Sigma eC = \Sigma EC$), but no other current will. But we need not be misled by C = 0 being, in this case, the only other solution than the real. For if we introduce a shunt, making three wires joining two points, and have an impressed force in only one of the wires, we may create additional solutions without number. For two simple circuits can be made containing the impressed force, furnishing two extreme solutions, in which no change from the real current is made in the current in one or the other branch not containing the impressed force. Between these extremes, by changing the current in all three branches suitably, we get any number of other solutions, in all of which continuity, Ohm's law, and conservation are satisfied. The heat varies from zero up to a certain maximum, which occurs in the real case; then the auxiliary force is completely polar, or has

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a potential. Of course, did we ever find a seeming departure from the proper distribution of force related to the known impressed force, we should naturally ascribe it to *other* impressed forces, and so come back to potential again.

(To be Continued.)

BEHIND THE SCENES AT HER MAJESTY'S THEATRE.

The performance of the "Excelsior" ballet at Her Majesty's Theatre is an interesting one, viewed from a scientific as well as from a theatre goer's standpoint. In the first place, the story it unfolds and the moral that it teaches are both intimately connected with the traditions that guide us and the aspirations which urge us all to constant application and to renewed research. The second point of interest is a purely technical one, viz., the essentially practical application in this country of the arc light to purposes of stage illumination and stage effect. When installing the electric light, with all its accessories in a theatre, two great difficulties have to be met and to be overcome. The possibility of such requirements has not been contemplated in the construction of the building, and space, therefore, is limited. The engine and dynamo must be stowed away in a hole or corner, and yet in some position where they can be got at, and which meets with the approval of the insurance people. That is one difficulty. The second is perhaps less easily dealt with. The arcs must be at the wings, in a convenient position for handling when required, and yet so arranged as to be out of the way of the performers, scene shifters, scenes, and the various paraphernalia which cumber up almost every available inch of space at each side of the stage. These difficulties, suffice it to say, for the present have been surmounted, without expense, and by no other means than ingenuity and perseverance.

The opening tableau of the ballet is entitled the "Spirit of Darkness." The stage represents a Spanish town in ruins. A funereal night—a lugubrious silence only interrupted by the sounds of a bell inviting prayers for those who are condemned to perish at the stake. The Inquisition is all powerful. Terror reigns on all sides. The Genius of Darkness is rejoicing; he holds at his feet, conquered, a woman in chains. It is "Light!" "Thou," says he, "who wert at one time the glory, the progress, the civilisation of the whole world, behold what my power has effected! Where are the splendours of past ages? I now reign, and shall reign for evermore. Never shalt thou break thy chains." Suddenly Light revives. A mysterious power imparts to her a new life, her countenance brightens up, her chains fall off before the bewildered gaze of the Spirit of Darkness, and in prophetic tones she says to him:—"Thy reign is over, and the Future is mine. Thou shalt no longer spread discord and hatred among Mankind. Men shall soon speak to and understand each other from pole to pole. Thou shalt lie crushed by sublime discoveries, gigantic works, unexpected marvels." "No," cries the Spirit of Darkness; "I believe not in these marvels of the Future. And even were they realised I shall stand forth to combat and annihilate them." "Look," says Light; "look, and prostrate thyself before the Genius of Humanity." The scene is transformed; Light and Civilisation are united on the Terrestrial Globe in the Palace of Genius and Science.

The second tableau is called "Light," the scene being the palace of Genius and Light. In this palace, dazzling with riches and splendour, are gathered together the glories of all ages. In letters of gold are inscribed all the great works of modern times. Steam power, the Telegraph, the Isthmus of Suez, Mont Cenis. A new existence is opening for Mankind.

At the conclusion of this tableau, "Light" (Signorina Desovino) bears aloft a very ingeniously constructed portable arc lamp, the first we have had the pleasure of seeing. (Fig. 1.) It is a very neat and very effective apparatus, striking its own arc, giving a light of some 3,000 candle-power, and burning for about four minutes for each arc formed. We are not at liberty to disclose the details of its construction, but we cannot forbear to congratulate Mr. Shepherd, the electrician, upon the admirable manner in which his simple invention fulfils the required conditions.

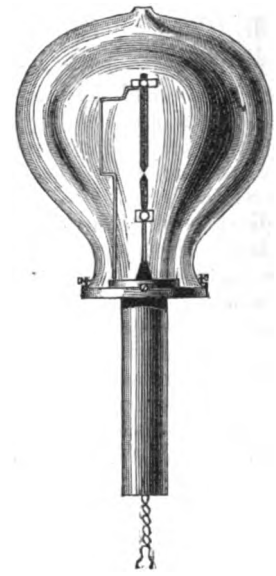

FIG. 1.—The "Excelsior" Hand Arc Lamp.

The third tableau represents "The First Steamboat," followed by the fourth tableau, representing "The Prodigies of Invention"; while the fifth depicts "The Discovery of Electricity." In his laboratory at Como, Volta, absorbed in thought and full of anxiety, is seated before his instruments. He is working, seeking, but cannot find. Something is still wanting to complete the wonderful discovery that is to transform the face of the Earth. A new thought flashes through his mind; he tries new experiments, and the electric spark appears. He falls on his knees, and offers up his thanksgivings to God. The Spirit of Darkness rushes towards the battery to destroy it, and receives a strong electric shock. He recoils. He remains for a while confused, paralysed—then darts forward again; but the Light interposes, and shows him the effects of this marvellous discovery.

The apparatus used for the demonstration of the "electric spark," or rather "arc," is of the simplest kind, it having been

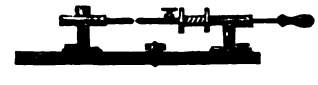

FIG. 2.

devised and constructed by Ernest Moy, nephew and pupil of Mr. Shepherd, and a lad apparently of sixteen years or so of age. This youngster acts, not only as assistant electrician, but is mechanician, stoker, engineer, and so on—a responsible and evidently capable person.

The sixth tableau, "Electricity," is laid in Telegraph-square, Washington. Light and the Spirit of Darkness are borne to the Central Telegraph Office at Washington. A crowd of little telegraph messengers come running out of the office. Light is triumphant and the Spirit of Darkness takes to flight blaspheming.

The remaining five tableaux continue to illustrate the progress of civilisation and the final defeat of the Spirit of Darkness and Ignorance; but for these it will be sufficient to mention that in the last tableau "Light," mounted upon a lofty pedestal, and bearing in her hand the "Excelsior" arc, crowns a very effective scene, and closes a fine performance. The light given by the ten arcs at the wings throughout the evening was extremely good, but not quite up to our idea of what should have been given by 20,000 candles. The so-called 2,000 candle-power lamps are probably nearer 600 candle-power than the former amount. The most remarkable thing about this installation, however, is the practical, the rough and ready manner in which it is worked. A good serviceable engine—an

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8 horse-power Clayton and Shuttleworth portable—is stowed away in a narrow space adjoining the stage entrance, leaving just enough room for the dynamo, a piece of ¾in. india rubber tubing (feeding the boiler from a hydrant near by), and the engineer. The 8 horse-power is fitted with an enormous chimney, 70ft. in height, and a feed-tank of Lilliputian dimensions. There are no resistances whatever in the circuit, and not a switch-board or switch in the theatre; the leads being taken direct to the lamps, and any alteration such as would be caused by the extinction of any of the lamps being compensated for by "slowing down."

Just before the commencement of the performance an electric bell, actuated by the gasman at the wing above, notifies the youthful electrician to "stand by"—standing by, in his case, meaning the rapid adjustment of a brush to the dynamo; while a second ring has the effect of producing the burst of light which is such a valuable adjunct to spectacles of the "Excelsior" kind. The lamps used are the Maxim-Weston, arranged by Mr. Shepherd, whose knowledge of the application of the electric light to stage effect is probably unique.

We may mention that the whole of the work has been carried out in accordance with the Phœnix Fire Office rules, and has received the approval of Mr. Heaphy.

CORRESPONDENCE.

THE KAUFFER AND GOLDNER BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Like very many of the statements put forward in relation to batteries for electric lighting, the paragraph relating to the "Kauffer and Goldner" battery, quoted from an American source in your last issue, is somewhat difficult of mental deglutition. It would seem to imply that 2,432 candle-hours were obtained by the consumption of 4½lb. of zinc. Now, a pound of zinc cannot possibly be made to generate, even under theoretically perfect conditions, more that 1·14 horse-power hour; and 4½lb. of zinc could not, therefore, generate more than 5·13 horse-power hours. No result obtained in practice could even approach this figure. We are therefore called upon to believe that 2,432 candle-hours have been obtained by the expenditure of considerably less than 5 horse-power hours, presumably with an incandescent lamp. It would be interesting to know what lamp was used.—Yours, &c., DESMOND G. FITZGERALD.

DOUBLE-POLE SWITCHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It was with pleasure I read in one of your contemporary's last week's issue a letter by Sir David Salomons advocating the use of double-pole switches in installations generally, and more especially where accumulators are employed.

Notwithstanding the many obvious advantages in favour of such switches they have been but little used in England, although in America, where electric lighting has taken such a firm hold, experience has demonstrated not only the desirability, but in many instances the actual necessity of using them.

Whether in large isolated plants or in central station lighting, the larger the number of lamps and the more extended the net work of wires so much greater has been the resulting gain.

The same remarks apply quite as much if not more to the use of double-pole "safety cut-outs," the additional facility in localising faults much more than compensating for the slight extra cost, and they have the cordial approval of Mr. Musgrave Heaphy from a fire insurance point of view.

That the advantages obtained are not of a mere hazy but of a material character is proved by the fact that in all the installations made by the Edison Company in America nothing but double-pole cut-outs and switches are employed.

An efficient switch must always be an important factor in a good installation, and in spite of the multifarious claims to perfection, it is only too well known that but very few switches will stand the test of time. In a double-pole switch considerable difficulty is experienced in constructing one that will fulfill all the requirements of strength, room for wires, good contact, and sharp "make and break," &c., and yet will at the same time be neat and not cumbersome.

The double-pole switches, which have been now extensively used for some time in America, are manufactured by Messrs. Bersmann, Edison, and Co., who manufacture all the Edison electrical fittings. Messrs. B. Verity and Son having been appointed their special agents in England, and being convinced that in a short time only double-pole fittings will be employed, have brought them under the notice of numerous electricians. A considerable number have been supplied for the large installation at the Hotel Metropôle, and they have the assurance of the electrical engineer, Mr. Holloway, that with such an extensive run of wires, and with workmen continually damaging them, the double-pole safety cut-outs more especially have been of immense service to him in coping with such difficulties.

In all the installations and wiring that our firm is at present carrying out, such as the Naval and Military Club, and the Criterion, &c., nothing but double pole fittings are being used, and I for one am sure that this is a step in the right direction of improved efficiency.—Yours, &c., JOHN B. VERITY.

31 and 32, King-street, W.C., Aug. 17, 1885.

A SILENO-DIFFERENTIAL RECORDER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Thanking you for the description of my patent Sileno-Differential Recorder, I wish to draw your attention to the fact that I have succeeded in overcoming an objection often raised against it that in the event of earth currents moving zero the apparatus would cease to work properly. This I have done by adopting an improvement suggested by Mr. N. Blackwood-Price, Superintendent of the Eastern Telegraph Company's Station, Trieste, by which the possible error of a moving zero is completely eliminated. I intend to bring my apparatus before the public at the next electrical exhibition of importance. Kindly insert this notice as appendix to the description of my apparatus you have given.—Yours, &c.,

VON TAUND-SZYLL.

SOURCE OF ERROR IN WEIGHING SMALL QUANTITIES.—A curious source of error in weighing delicate quantities has, according to our American namesake, latterly been discovered by a German, Mr. Hennig, of Wurzburg. Owing to a supposed error in results, Mr. Hennig made careful investigation, and found that the scales he was making use of were affected by the electrical condition of the rectangular glass shade which covered and protected the balance. The lever of the balance carries small sliding weights, called "riders," by which to obtain more delicate divisions than can be arrived at by arbitrary weights in the scale pans, and he found that wiping the glass shade above these produced sufficient electricity to raise them from the beam. Rubbing the shade lightly with a linen dusting cloth displaced the zero pointer several lines, while with silk or woollen cloth this error was materially less. The amounts of error thus engendered are shown as follows:—After the first rubbing of the shade the electrical charge held balanced 600 milligrammes, and at the end of two hours still balanced a weight of 10 milligrammes; while with silk or woollen rubbers, under identical conditions of the atmosphere, the charge was balanced by 150 milligrammes and 70 milligrammes respectively. The charge was dissipated by a Bunsen flame, instantaneously applied. Mr. Hennig purposes remedying the difficulty by attaching to the under surface of the glass shade a metallic grating with an earth connection, so that an accidental charge will be disposed of before it can do mischief.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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TELEGRAPH CONFERENCES.

The final results of these periodic Conferences are of the greatest importance to civilised nations. There is a danger, however, especially to be feared when private interests are considered, seeing that these private interests, as we have before pointed out, can only have a vote at second hand. It is not to be expected that all differences will be settled by any number of conferences—at any rate till the Millennium has arrived. Nor must we forget that two distinct questions, scientifically and commercially, have to be considered. The first concerns the land lines, or the land telegraphic system, belonging to the various States; the other, that of the cable system, belonging practically to private companies. No doubt there has been a good deal of friction relating to the transmission of telegraph messages by land lines across the various frontiers; but very much of this has already been remedied, and what is evident at this Conference is that the settlement of many of these minor differences among the States and the Companies, which correspondence has failed to effect, will be arranged. These periodic meetings bring together the principals who control the various systems, and what was difficult, owing to distance, and could hardly be arranged by correspondence, becomes easy when it is possible to meet together and verbally exchange opinions. The result of all Telegraphic Conferences hitherto held has been to formulate certain rules and tariffs generally acceptable to those interested, and although as yet the Conference now sitting has not decided any single point, all the subjects are being well ventilated, and the instructions and opinions of the eighty delegates are being understood by each other, so that there is no reason to apprehend that the Berlin Conference will fail to establish some marked improvement in telegraphic operations.

With regard to the German proposition for a uniform tariff, which we referred to in our last issue, there seems to be very little doubt that it will not meet the approval of the delegates. The land lines are principally owned by the various Governments, and too many of the States are already struggling under the effect of a great deficit in their receipts for telegrams, so that such States as Russia, Italy, France, Austria, &c., are not prepared to accept any proposals by which they would increase that deficit to any appreciable extent. It may be, however, that some slight concessions could be made towards the proposal, more, perhaps, in a conciliatory spirit than from any real agreement with the principle. The main feature of all the discussions, both at the general Conference and at the numerous small gatherings, has been the question of how far the States and the Companies can be persuaded to reduce their tariffs, and how far could the principle of uniformity be adopted. It has, we understand, been strongly urged that all the States, feeling confident that the principle of the uniform tariff is correct, should of themselves adopt such a tariff, and leave those who do not at present adhere to this conclusion to further consider the question at some future time, and adopt it when practicable. We are inclined to think that a universal uniform tariff is an impossibility, and that some other basis of agreement will be found.

It is said that there are one or more projects believed to be generally acceptable, which will in the first place be considered by a sub-commission. The Companies have long known that a general reduction of their rates would be among the proposals to be urged, and subject to the various States, India, and the Colonies bearing their due share of the burden, the delegates have declared their readiness to advise their various Boards to agree to a substantial reduction of tariff. The reduction that the Companies can consent to depends in a great measure upon the definition of code language and the nature of the restrictions which shall regulate Press telegrams, if the latter are still to be accepted at reduced tariffs. Our readers know full well that the art of coding messages has arrived at almost a state of perfection; still, some people may not be aware that cases are known in which sentences consisting of over 120 words have been sent by means of one single code word. The pioneers of submarine telegraphy have had to meet and to overcome, for the benefit of their shareholders, the loss to revenue which they could not foretell, but which has arisen because of the coding system.

These commercial questions have been put forward again and again; but there is another view of the matter which, as yet, has not been duly considered. It is that so far as cables are concerned there is a limit, and a limit very soon reached when compared with land lines, to the number of signals that can be transmitted in a given time. When we deduct the time occupied by repetitions, and the time occupied by messages relating to the companies' own affairs, we can easily determine the maximum number of words of a given length that can be transmitted per day, and can as readily determine the price which should be paid per word, if such a maximum number of messages could be obtained. Hitherto a reduction of tariff has always resulted in a loss of revenue, and though we may talk a good deal about the interests of the public, simplicity of regulations, uniformity,

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and general reductions, all these mean reduction of the revenue of the companies, leaving them the hope which "springs eternal in the human breast"—the hope of augmented traffic resulting from the changes. The whole subject is one which gives the gravest anxiety to the representatives of the Companies now at Berlin. When the general taxpayer has to pay the losses which result from Government business there is no end to the purse; but it is quite a different matter when private companies are compelled against their own convictions to attempt to comply with a system the benefits accruing from which are benefits principally to a class quite able to take care of itself, and quite able to pay for the services it requires.

SHIP-LIGHTING BY ELECTRICITY.

BY W. H. SNELL, A.S.T.E. AND E.

The electric lighting of ships engaged in the passenger service has become so general and is so highly appreciated by travellers that steamship owners are discovering the necessity of adopting this method of illumination even for second or third class vessels. The writer proposes to offer some remarks and suggestions which are likely to be of interest to owners of steamships who have adopted or are about to adopt the electric light upon their vessels. These remarks will aim at being of a very practical but quite untechnical character, and will to a large extent embody the experience which has been gained while having charge of an extensive series of installations on ship-board. These installations comprise altogether nearly thirty dynamos (of different types), several thousand glow lamps, and a few arc lights.

Among these ships is one which I believe was the very first to be lit by electricity, and it says much not only for the firm who undertook the work, but also for the method itself, that the original arrangements continue to work satisfactorily down to the present time. Nevertheless, as may easily be supposed, any modern installation will differ very widely, in almost every detail, from this early specimen. In certain departments of electric lighting—as, for instance, in the supply of electricity from house to house—we may still look for great advances, but this is certainly not now the case with regard to ship lighting. While it would be too much to assert that absolute finality has been reached, yet it is quite certain that no very great improvement remains to be made in any important detail. The only substantial gain that may fairly be expected in the near future would arise from a reduction in the price of glow lamps. But as the cost of lamps comes under the head of working expenses, we can take advantage of such reduction whenever it may come.

When any given ship is to be lit, the first question to be considered is to find room for the engines and dynamos. The position selected should be as cool and well ventilated as possible, should either be a part of the engine room itself, or readily accessible from that room, and should admit of steam connection with the donkey as well as with the main boilers. In a new ship a space upon the main or spar deck immediately forward of the engine room usually fulfils these requirements as far as possible. In vessels already built it is frequently possible to appropriate the oil room, which generally occupies the position above described. If there is no available space 'tween decks it will be necessary to get down upon the floor of the engine room, or in the last resort to cut a space out of the coal bunkers. But in this case it will usually be difficult or impossible to make use of the donkey boilers; the temperature will be much higher, and the machines more exposed to dirt and accident. The connection with the donkey boilers is only *necessary* when it is desired to use the the dynamos while in port, but if (as I fully anticipate) electricity is by-and-bye used on ship-board for other purposes than lighting, such facilities may come to be considered indispensable. For this and for other reasons I would venture to say, "Don't put your machines on the floor of the ship if you can possibly have them higher up."

Having determined the best position for the machines, consider next the choice of engines and driving gear. This selection will largely depend upon the amount of space available and upon the speed at which the dynamo has to be run. This speed may be anything from about 300 revolutions per minute up to 1,000 per minute, or even higher. We will consider this point more in detail later. But supposing for the present that we know the required speed, we have (principally) four available methods of driving the dynamo.

(1.) By coupling direct to a high speed engine.

(2.) By rope gearing with grooved pulleys.

(3.) By a short belt run over a tightening pulley.

(4.) By friction gearing.

An internal cog wheel gear has also been tried with some success, but of this plan the writer cannot speak from experience. One would suppose that the noise would often be very objectionable.

(1.) The first plan has much to recommend it, especially where space is limited. The absence of gearing in any shape or form also entirely obviates one possible cause of break down. There is more than one pattern of high-speed engine which works with remarkable smoothness and gives wonderfully little trouble, frequently running for months together without being overhauled. The consumption both of oil and steam in this class of engine is relatively rather large, but on a big ship the cost of steam for this purpose is not a matter for very serious consideration, although it cannot be altogether overlooked. In the earlier forms of high-speed engine the quantity of oil required was sometimes rather alarming, but in the later patterns this has been reduced (in all cases that have come within my knowledge) to very reasonable limits. When this plan is adopted it is a decided advantage to make use of a flexible coupling between the shafts of the engine and dynamo. One advantage of this form of coupling is that it tends to compensate for any small want of truth in setting the machines in line.

(2.) The system of driving by cotton rope gearing requires considerably more space, but it permits of the employment of a somewhat more economical class of engine. It is necessary in this case that the machine be mounted upon a sliding bed, to permit of the ropes being tightened whilst running. The ropes should always be protected by being boxed in as far as possible. They may be kept in good condition by being liberally treated with a mixture of black lead and tallow—as there are usually upwards of 10 or 11 turns of the rope there is little or no slip even with the grease. The ropes should, of course, be frequently examined, and should be renewed long before there is any chance of their being outworn. A case came to my knowledge in which, from lack of the precautions here mentioned, a rope gave way, and lashing around a dynamo destroyed the machine.* Still, with reasonable care, I believe the method to be quite trustworthy. In the two instances under my charge there has never been any trouble of any kind with the ropes.

(3.) The third method of driving, that of a short belt passed over a tightening pulley, should also prove satisfactory enough when properly applied. So far as my own experience goes I am only acquainted with one set of two machines fitted with such gear, and they were under my charge only for a short time. In this case link belting was employed, and some trouble was caused with one of the machines by the belt breaking more than once. But this particular case was probably not a fair test of the method. The whole installation had been unsatisfactorily laid out, and I had reason to believe that, owing to defective insulation, the dynamo was doing far more work than was bargained for. Link belting is certainly the right thing to use in this case, where the belt is bent in each direction.

(4.) The fourth method is that of friction gearing. The arrangement introduced by Messrs. Siemens Brothers and Co., in which the dynamo pulley is faced with papier-machie and runs upon a larger wheel upon the engine shaft, gives excellent results. I am not aware up to what power it has been

* I was shown pieces of the machine in a hamper, but was not able to investigate the facts.

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worked successfully. I have not used it for transmitting more than about 6 horse-power. This gearing should be boxed in, or some day an oil can will be placed upon the wheel just as the machine is about to be started; such an incident would produce much inconvenience.

We will next consider some of the points of a good dynamo for ship lighting. First, it is desirable that it should be "compound wound," in order that it may be self-regulating; that is, in order that the same current may be supplied to each lamp, no matter what number of lamps may be burning. It therefore follows that we should prefer a continuous-current machine to one giving alternating currents, as the latter cannot be made self-regulating—at least not in this simple way. It is true that very good results have been obtained in ship-lighting by alternating machines, but the special advantages claimed for them—such as absence of sparking—are now equally well secured by almost any modern continuous current machine for incandescent work. Electrically speaking there is very little to choose between the six or eight different machines of the leading makers. They none of them convert into electricity much less than 80 per cent. of the power supplied at the pulley. It is chiefly important to be satisfied that the mechanical construction is good, that the machine is capable of standing a certain amount of rough usage, and also that it can make a run of at least eighteen hours without overheating. For a reason to be mentioned later it is also desirable that the insulation resistance between the wires and the frame of the machine should be as high as possible. This point is of much greater importance in ship lighting than ashore, although it is not one upon which a purchaser can very readily satisfy himself. The armature should be capable of being easily removed and replaced by the engineers of the ship. It is, or should be, very seldom necessary for this to be done; still, it is as well to carry a spare armature in case of accident. The commutator (that is, the small copper bars which are set around the armature shaft at the end opposite to the pulley) should be an inch or so longer than the width of the brushes which bear upon it. And the brushes should be capable of being slightly shifted in their holders along the line of the armature shaft. By this means, if the position of the brushes is slightly altered at frequent intervals, any grooving of the commutator is obviated. If, as is preferable, there are two brushes side by side it is desirable that the brush holders should be capable of independent adjustment. Unless this is secured it will be necessary always to use brushes of almost exactly the same length in each holder. Possibly in some later machines this point is of less importance than formerly. I have usually found a plain flat brush made of copper wire much cheaper, and more easily adjusted by the men, than those made of copper strips with slant cut ends. The flat brush can be used down to the stump, while the other cannot; it is, however, necessary that the men should understand that it is not desirable to economise in brushes at the expense of the commutator.

Continuous current machines have armatures approximating towards one of two types, usually known as the disc and the drum. There are several well-known machines of each type, between which it may be difficult to make a selection. If in any case all other things are substantially equal, it is, perhaps, well to choose the disc type, mainly on the ground that the armature is more accessible for repairs, more likely to have a true balance, and more easily ventilated. Still, there are very fine machines with drum pattern armatures.

In order that the rolling of the vessel may not have a prejudicial effect upon the bearings of the armature shaft, it is desirable that the machine should be set with its spindle fore and aft, and not athwart ships. It should also be noticed whether the oiling is likely to be efficient under any probable list that the ship may receive. A special oil is made for use with dynamo machines. This oil is free from the acid which is usually present in machine oils, and which tends to affect the insulation of the coils.

As we have already said, if the machines are "compound wound" practically the same amount of current will pass through each lamp, no matter how many lamps may be burning. This, however, supposes that the dynamo is always driven at the same speed. If the speed increases to any extent, the current through each lamp is increased possibly so much as to destroy the filament. In any case the result will be to shorten the life of the lamp. Now there are two causes which tend to vary the speed of the engine. The first is a change in the steam pressure; the second is any alteration in the load, that is in the number of lamps alight. In order to compensate for change of steam pressure, the engine must be fitted with a governor sufficiently sensitive to maintain the proper speed within the permissible limits under any probable variations of pressure. And in ship-lighting, if the governor is capable of doing this, and if other things are properly arranged, we need not trouble ourselves very much about the second source of irregularity in speed. In giving this as my opinion I am perhaps diverging from the views expressed by some of the highest authorities. But the case usually considered is one in which, from my point of view, the other things alluded to above were *not* properly arranged, or at least not as well as they probably might have been. There are, in fact, two conditions which must be fulfilled in order that we may dispense with an automatic regulation of speed, so far as variation in the load is concerned. The first condition is that the circuits should be arranged so that every dynamo supplying any state room lamps should also supply a certain number of "ship" lamps. Now, the state room lamps, including those in the officers' berths, alone are liable to be turned "off" or "on" at pleasure. All other lamps which I call "ship" lamps can very easily be placed under the charge of some one, who alone should be entrusted with the duty of switching the lamps on or off. The lamps in the saloon, smoking room, ladies' cabin, engine room, stokehole, passages, &c., will almost all be lit at dusk, and will only need to be extinguished at some given time.

Most of these lamps will be turned on or off in batches, and not one at a time. Under these circumstances it is only necessary that the lamps should not be switched off until warning has been given to the man at the engine. He then *first* slows down the machine so as to perceptibly diminish the light; this acts as a signal to the other man that he may now proceed to switch off the lamps, and the driver finally readjusts the proper speed. By this simple plan it is impossible for the engines to race when the load is diminished. As for the state room lamps whose use is left at the discretion of the passengers, by taking care that as far as possible they are supplied by machines which are *also* running ship lights, we have a guarantee that the load will never be unexpectedly increased or decreased except by a certain small ratio. The maximum value of this rate per cent. is known, and in practice of course we never get more than two or three lamps extinguished at once, so that the speed can easily be kept right by the man at the engine.

From what has been already said it will be understood that a tachometer, to indicate the speed at which the engine is running, is an indispensable part of the equipment. These instruments require, however, to be carefully cleaned and oiled at regular intervals if their indications are to be relied upon. It is very desirable to check them occasionally with a counter or speedometer. It is also necessary to run a pilot lamp from each machine; the lamp and the tachometer then to a certain extent act as a check upon one another. If, however, the lamp should become over bright while the tachometer does not indicate an increase of speed, it is better to believe in the lamp. I once heard of a man who was of a different opinion. His tachometer having struck work he drove up the machine until the lives of several lamps came to a sudden and untimely end. Such a man should be promoted at once to another sphere of labour.

Before we quit the engine room there are still one or two points that may be mentioned. It is better to employ at least two separate machines rather than to rely altogether upon one. Then, if an accident does happen to either machine we can still keep the saloon and the engine room lit up. It is often convenient in large installations to employ two machines of equal size, together with one smaller one. We can then use the small machine alone for the lamps which are kept burning all night, or for such work as running an arc light upon some special occasion.

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As to the best speed for ships' dynamos it should be remembered that very slow machines are as a rule not so efficient as those which run faster. "Very slow" may be taken to mean anything less than 400 revolutions per minute. However, anything up to 800 revolutions, or even higher, may be accepted.

We will now proceed to consider the "wiring," which is one of the most important parts of an installation. It is most essential that the wires should be of sufficient size, and that they should be thoroughly well insulated and sufficiently protected *in every part of the ship*. If they are not large enough some of the heat which ought to be generated in the lamps will appear in the wire instead. If the insulation is not good enough, not only is there a leakage of current, but in the presence of moisture the wires tend to corrode. It is, however, quite a simple matter to provide most thoroughly against each of these dangers. The proper sizes of wires so as to unite economy with perfect safety are now thoroughly well understood. The insulation of the wires may also be relied upon so far as the electric properties are concerned. It is, however, desirable to insist upon the use of an insulation specially prepared to withstand the action of damp and sea salt. But even when this class of wire is employed it is very desirable that the wire should be protected as far as possible from exposure to sea water. In some early installations this protection was very effectively secured by enclosing every wire in iron piping. This plan has, however, so many disadvantages that it is impossible to recommend it. It is very expensive, it takes about five times as long to put up, it is not nearly sufficiently flexible, and when the wires are once safely enclosed it is next to impossible to get at them again. The only places where tubing is sometimes really necessary is in the engine room and stoke hole. Even there I much prefer to use an insulated conductor, bound around outside with a strand of galvanised iron wire. This plan was first introduced by a Glasgow firm, and it is a distinct improvement. In other parts of the ship, wherever, from damp or other causes, wooden cleating is not a sufficient protection, lead cased wire may be used with great success. In the Royal Navy they are now trying the plan of sinking the wires in wooden grooves, and filling in with white lead or some similar composition. This method may be expected to answer in places where the wires once put up are never likely to be disturbed; but in the merchant service, so far as my own experience goes, such finality is frequently unattainable, and for one reason or another the wires have often to be reached. I therefore much prefer, whenever any special protection is required, to have the protection attached to the wire itself, and I have found the lead covering to answer every purpose. It is not very expensive, it resists salt water, and it is easily removed at any point when a joint has to be made, and as easily replaced.

It may be worth while in this place to draw attention to the necessity of seeing that all the wires, brackets, switches, &c., are attached only to the permanent fittings of the ship. To those who are acquainted with the exigencies of the merchant service this will not seem a superfluous recommendation. I have known a case in which a new ship was fitted with about 500 lights. About 100 of these were placed in the state rooms and passages on the lower deck, and were attached to the wooden partitions in the usual manner. But as soon as the ship commenced running it was found necessary to use the lower deck for stowing cargo upon the outward voyage. For this purpose every vestige of the state room fittings was removed at the home port and replaced at the foreign port on each voyage. It was therefore necessary to supply an almost entirely new set of fittings for the lower deck, and to attach the whole to the iron beams or other permanent structures. Of course much expense would have been saved had this been done in the first instance.

Another thing which requires special care in this connection is in passing the water-tight bulkheads. This is a point at which no liberties can be taken, and the wiring should be arranged so as to traverse these partitions at as few points as possible. For the largest cables a stuffing box may be employed, but it is usually sufficient to pack the cable with wood, which can then be swollen. Upon the main deck it is sometimes best to go *over* the bulkhead instead of going through it. For this reason, among others, I distinctly prefer the "single" wire system in which the current returns to the machine through the skin of the ship. We have therefore little more than half as much wiring to put up, and, of course, the cost is proportionately less. In common, I believe, with most electricians I looked upon the single wire system with much distrust when it was first introduced. But also in common with almost all who have had experience of both plans I am now prepared to give it a decided preference. The advantages alleged in favour of the double wire are that the total insulation of the system is considerably higher, and that the chance of "short circuits" is very much reduced. But if other details are properly arranged, the chance that a "short circuit" will occur, or that it should do any harm if it does occur, may be equally disregarded upon both systems. I am acquainted with a ship in which one part was wired with double wires, and at a later date the lower deck was fitted with single wires. As a matter of fact the only troubles as to insulation that have occurred have always been with the double wires; and this has, I believe, been the experience of others under similar circumstances.

When a single wire is used it is necessary to connect the other terminal of the lamp to the ironwork of the ship. For this purpose a connection is made between one side of the lampholder and the metal work of the bracket. If the bracket is attached directly to the ironwork this is all that is required, but if not an uncovered copper wire is taken from the bracket to the nearest convenient point, and there secured between two copper washers which are threaded upon a $\frac{3}{8}$in. screw tapped into the iron. It will then be impossible for any one to obtain sparks from any part of the bracket while the current is on.

It was in view of the employment of this method that I said that it was desirable that the insulation between the brushes and the iron frame of the dynamo should be higher for ship lighting than for shore work. If, however, the dynamo is bolted upon a separate foundation, it is possible to insulate the whole machine from the ship more or less effectively. But obviously this cannot be done when driving direct from a high-speed engine, or by means of friction gearing, or in any case where the engine and dynamo are upon the same bed-plate.

As we have now got back to the engine room, we may consider next the switches and safety fuses which are there required. The particular pattern of switch-board which should be adopted will depend upon the size and character of the installation. It is desirable that facilities should exist for running any one of the machines upon any one of the circuits, and for making such changes rapidly when necessary. If, however, we have machines of different sizes, we must be careful to make it impossible to run the smaller machine upon circuits containing a larger number of lamps than it is meant to carry. It should also be impossible to place two machines upon the same circuit at the same time. It will usually be necessary to make use of some form of plug switch-board. In this, the connections are made by placing brass plugs in holes slightly countersunk on a system of cross-bars. The bars should be mounted upon a slab of slate, or some other incombustible insulating material. It is very necessary to adopt some plan for locking the plugs in their positions; there are several methods in use all about equally good. The plugs should be kept perfectly clean, and a spare set should always be at hand. Whenever possible, it is much better to slow down the machines before shifting plugs. For large machines it is best to have a good make-and-break switch in the main circuit as well as the plug board.

A safety fuse should be placed in the main circuit of each machine; it should always be connected between the machine and the switch-board. It is desirable that these main fuses should be of some form which, while preventing injury to the machines, will not be liable to cause unnecessary interruptions to the circuit. Such arrangements have not yet come into very general use, but there is no reason why they should not be insisted upon.

In other parts of the ship the switches are mainly of two kinds, those for single lamps, which frequently form a part of the bracket, and "section" switches, one of which is usually supplied for each distinct group of lamps, and is generally turned by a key. The essential thing to be required in these

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switches is that they should always stand either full on or full off. Any switch which will remain in an intermediate position should be condemned, for it will very likely cause sparking. It is not desirable to have too many lamps upon one section switch; the lamps in the saloon, for instance, should be divided into groups of, say, 30 or 40, and each group should have a separate switch. It is customary to divide the state rooms in the same way into sets of 15 or 20, and to provide each set with a section switch in addition to those attached to the lamps. This plan requires more wire, but it presents several advantages. It enables us to cut out any part of the installation which may have received serious damage, so that it shall not interfere with the working of the remainder of the lamps. Besides this it obviates the use of a special set of wires for the "night light circuit." Those lamps which (in this part of the ship) are to burn all night may be connected with the positive side of the switch. These lamps are therefore still connected with the machine after the switch has been turned off. The plan has a further advantage, inasmuch as after turning on the section switch a light may be obtained in any state room if required at any time of the night. All switches should be carefully cleaned at intervals.

It may be taken as a general rule that wherever there is a switch there should also be a safety fuse; and the fuse should be upon the side next the machine. For lamp switches and for all section switches, except those of the largest size, the fuse may be of the simplest character. I have always found that lead wire answers the purpose admirably, although probably a thin strip of tin is better still, at any rate for section switches.

With regard to lamp brackets there is little to be said; their style will, of course, depend mainly upon the character of the ship's fittings. For the state rooms it is better to have bracket, fuse, and switch all in one piece. In the saloons it is a good plan to have three-branched pendants over the tables, so as to avoid throwing the shadow of the glass holders (which usually hang alternately with the lamps) along the tables. Until recently it has been the general custom to make the same bracket carry both oil and electric lights in the saloon. However, now that greater confidence is felt in the electric light, this is being abandoned, much to the advantage of the latter. If in any case it is still considered necessary to supply oil lamps, the brackets will of course have to be very much heavier articles. It is then desirable to see that a special metallic connection is made with a piece of copper wire between the bracket and the iron beam from which it is hung. If this is not done, after a voyage or two the lamps will often go in and out as the ship rolls, owing to the bracket not making good electrical connection with the iron. This remark of course applies only to the single wire system. In the engine room the brackets should be very short, so as to project from the walls as little as possible, and it is desirable to enclose them in wire protectors.

It is often desirable to have facilities for carrying portable lamps into certain parts of the ship. For this purpose the best plan is to have pairs of terminal screws (with switch and safety fuse) placed at convenient points. These terminals should be enclosed in a wooden box provided with a lock and key. When required a piece of flexible double wire cable is attached to the screws at one end, and the other end of the cable passes into the portable lampholder.

The essential points of a good lampholder are that it should make thoroughly good contact with the platinum loops without putting an undue strain upon them, and that it should be easily fixed or detached from the bracket. It should also hold the lamp with a somewhat elastic grip, so as not to transmit the vibrations of the ship to the filament of the lamp any more readily than can be helped. When a lamp has to be changed the holder should invariably be removed from the bracket with the lamp attached; and similarly the lamp should first be connected with the holder, and then the holder with the bracket. In large installations attention to this rule will save a lot of breakages. In hanging lamps, especially high-resistance lamps with long filaments, it is better to place them so that the plane of the loop lies athwart ships. This will obviate the tendency of the loop to swing with the rolling of the ship. The carbon of the loop is probably in a semi-plastic condition while hot, so that its period of vibration is lengthened sufficiently to enable it to respond to the roll of the vessel. At any rate, I have found that, with high-resistance lamps, in upwards of 75 per cent. of lamps which have been burnt out the loops have given way at the place where the greatest strain would have occurred had they been subjected to such vibration.

I have as yet said nothing as to the selection of the incandescent lamp itself, possibly because there is at present very little to be said. It will be some time yet before sufficient data will have been accumulated to enable any one to give a distinct preference to any particular make of lamp. In the meantime we can only say that all the leading makes are very good—some day we may hope they will all be still better. One caution may be given. It is quite impossible to judge the intrinsic value of a lamp by comparing the light which it gives with that given by another lamp, even if they are both hung upon the same circuit. Indeed, in that case the chances are that the duller lamp is really the better of the two.

Lamps are specified by their candle-power and their voltage. Other things being equal, the higher the number of volts the smaller is the current required to give the same light, and therefore as the number of volts is increased the size of the wires may be diminished in the same proportion.

For ship-lighting 80 or 100 volts is about the thing. As to candle-power, 16 or 20 candle lamps are generally used, but in the state rooms and other small rooms 10 or 12 candle-power is ample. If we use these smaller lamps we must, however, be very careful to see that they take the same number of volts as those of higher candle-power which are supplied by the same machines.

It will be understood that the number of volts given by the dynamo machine when running at its proper speed is a fixed quantity. The lamps must therefore be ordered with reference to the machine. If the lamps require a number of volts greater than that given by the dynamos, they will burn dimly, if less they will soon have their filaments destroyed by the excessive current which would traverse them.

Arc lamps are very seldom brought into regular use in the merchant service. It is, however, a very good plan to carry a pair of such lamps capable of giving about 600 candle-power. They are extremely useful when any urgent repairs are required outside the ship. For this purpose two pairs of leads should be taken from the machine room, one to each end of the promenade deck. They should there be attached to a pair of terminal screws, enclosed in a wooden box with a safety fuse and a switch. A good length of well insulated double-wired cable of the proper size should be carried; the lamps can then be suspended in any position where they may be required, and the current can be taken from the terminals on deck. It is not desirable to try to run an arc lamp from a machine which is supplying glow lamps at the same time. For many purposes—such as for discharging cargo at night—a lantern which will hold eight or ten glow lamps is just as good and less troublesome than an arc lamp.

With regard to the maintenance of the installation, it is well that some one on the ship should learn how to make a good joint in an insulated wire, and should be able to take down and properly replace any of the brackets, switches, or other small fittings. This is about all they need know. A box containing the tools and materials required for jointing wires can be obtained complete, and the proper method of jointing is easily learnt by an intelligent man. In addition to this a few other stores will have to be carried, such as lamps and lamp-holders, a few spare brackets, switches, and safety fuses of each sort in use; several sets of brushes for the dynamos, one or two coils of insulated wire (principally of the size used for single lamps), and including also some lead-covered wire; and a supply of small articles, such as staples, copper-binding wire, sheet lead, &c. In ordering lamps it is well not to get too many at once, as among a large number there are sure to be some in which the vacuum will deteriorate if laid by for any length of time.

In concluding this paper I should like to repeat that these

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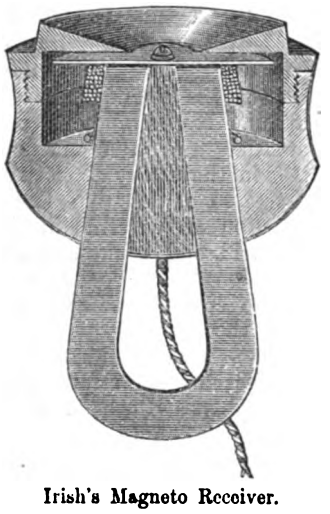
remarks are not intended for the instruction or information of electrical engineers, but it is hoped that they may prove of service to the large and increasing number of those who are making use of the electric light on board ship.

A NEW MAGNETO TELEPHONE.

On Saturday last we had the pleasure of inspecting a new magneto telephone, the invention of Mr. W. E. Irish, of Sunderland. The receiver, as will be seen by our illustration, possesses two novel features. The diaphragm is *centred*, giving presumably a higher degree of sensibility, or vibrating surface, and the coil is wound round both poles of the magnet; a block of wood between them serving as a support to and holding the diaphragm. The reason for this latter arrangement is not easily seen if it be other than a departure from recognised forms of construction. On the occasion of our visit, however, it worked very well indeed; the articulation being distinct



Irish's Magneto Receiver.

and clear. The transmitter proper—for the receiver can be used for both purposes—differs in some slight degree from the foregoing. We have to regret, however, that want of space compels us for the present to hold over a more detailed description of Mr. Irish's very interesting apparatus.

INFLUENCE OF EXTERNAL RESISTANCE ON THE INTERNAL RESISTANCE OF VOLTAIC CELLS.*

BY G. GORE, LL.D., F.R.S.

The present series of experiments were made for the purpose of ascertaining whether the total internal resistance of a voltaic battery varied with the amount of resistance in the external part of the circuit, and whether such change, if any, consisted of an alteration of the amount of ordinary conduction resistance of the exciting liquid.

The mode of experiment employed was to take a circular glass cup, 6·0 cm. wide and 4·0 cm. deep, partly fill it to an uniform height in every case with a mixture of five minims of nitric acid per ounce of water, at atmospheric temperature; wholly immerse in the liquid at a distance of 2·0 cm. apart, and facing each other, positive and negative plates of perfectly clean metal, each 1·0 × 1·0 cm., suspended by means of a narrow vertical strip prolongation of each metal; these strips being connected with an ordinary astatic galvanometer of 6·5 ohms resistance, which had been carefully calibrated by means of electrolytic measurements.

Two series of experiments were made, viz., one with a zinc positive and a series of different native plates; and one with a platinum negative and a series of positive ones; during each experiment the liquid between the plates being rapidly stirred by means of a revolving vertical blade of ebonite, to prevent polarisation. The electromotive forces of all these voltaic couples were first ascertained by opposing their currents to those from a thermo-electric pile of about 300 German-silver and iron elements (see *Pro.* Birm. Phil. Soc., Vol. IV., 1884, Part 1, p. 129); and their strengths of current were determined by means of the calibrated galvanometer. The measurements of strength of current were made—1st, without any added external resistance; 2nd, with 100 ohms wire resistance suddenly switched into the circuit; and 3rd, with 1,000 ohms instead of the 100. The total resistances were then calculated from the electromotive forces and strengths of current. The following tables show the results:—

* Read before the Birmingham Philosophical Society, June 11th, 1885.

TABLE I.

Influence of External Resistance on Total Resistance of Voltaic Cells.

Zinc Positive Plate.

E.M.F. Series.	——			With 100 ohms.			With 1,000 ohms.		
	Volts.	Ohms.	Amperes.	Ohms.	Amperes.	Excess of R.	Ohms.	Amperes.	Excess of R.
Cd. ...	·2131	12·68	·01680	120·40	·00177	7·72	1217·71	·000175	205·03
Pb. ...	·3901	118·93	·00328	203·17	·00192	15·76*	1182·12	·000330	63·19
Sn.	·4301	16·67	·02580	131·13	·00328	14·46	1162·43	·000370	145·76
Fe. . ..	·4867	25·61	·01900	148·38	·00328	27·77	1315·49	·000370	289·79
Al. ...	·5057	105·35	·00480	472·61	·00107	267·26	2580·10	·000196	1474·75
Ni. ...	·8571	66·44	·01290	167·40	·00512	·96	1142·80	·000750	76·36
Cu. ...	·8970	136·73	·00656	273·47	·00328	36·74	1196·00	·000750	59·27
Ag. ...	1·1490	347·25	·00328	746·10	·00154	296·85	1937·60	·000593	590·35
Pd. ...	1·1828	409·27	·00289	734·66	·00161	225·39	1994·60	·000593	585·33
Au.	1·4150	276·36	·00512	799·43	·00177	423·07	2386·19	·000593	1109·83
Pt.	1·4293	249·01	·00574	435·76	·00328	86·75	1660·05	·000861	411·04
Aver. .	·8142	159·40	·00965	384·77	·00254	124·65	1615·90	·000507	455·52

With this series, in every instance except the one marked,* the total resistance of the cell was increased by adding external resistance; the addition of 100 ohms external resistance increased the resistance of the cell an average of 124·65 ohms; and the addition of 1,000 increased it an average of 455·5 ohms. The smallest original total resistances were usually with negative plates of the most corrodible metals, cadmium, lead, tin, iron, nickel, and copper, and the largest with those of the least corrodible metals; the largest increases of resistance were also with the latter class; aluminium was an exception owing to its acquiring a film of oxide. As the whole of these resistances were calculated from electromotive forces obtained during a state of balance of current, they are all more or less magnified, especially the large ones.

The second series of experiments were made in a similar manner, but with a series of positive plates and a single negative one. The same liquid was employed. The following are the results:—

TABLE II.

Influence of External Resistance on Total Resistance of Voltaic Cells.

Platinum Negative Plate.

E.M.F. Series.	——			With 100 ohms.			With 1,000 ohms.		
	Volts.	Ohms.	Amperes.	Ohms.	Amperes.	Excess of R.	Ohms.	Amperes.	Excess of R.
Zu.	1·4293	75·52	·01900	404·90	·003530	229·68	2059·5	·000694	984·29
Cd.....	1·2162	147·41	·00825	513·16	·002370	265·75	2533·8	·000480	1386·34
Pb.....	1·0392	386·32	·00269	674·80	·001540	188·48	2811·4	·000370	1425·03
Sn.....	·9992	247·94	·00403	805·80	·001240	457·86	2700·5	·000370	1452·60
Fe.....	·9426	326·16	·00289	703·43	·001340	277·27	2547·6	·000370	1221·44
Al.....	·9236	2979·35	·00031	3800·82	·000243	721·47	5631·7	·000164	1652·36
Ni.....	·5722	1271·55	·00045	1546·49	·000370	174·94	3489·0	·000164	1207·47
Cu.....	·5323	1438·65	·00037	1438·65	·000370	100·00*	2715·8	·000196	277·16
Ag.....	·2803	2355·46	·00012	3389·36	·000083	933·90	5096·4	·000055	1740·90
Aver...	·8817	1025·37	·00423	1474·16	·001232	361·04	3287·3	·000318	1260·84

In every instance except the one marked* the total resistance of the cell was increased by adding external resistance; an effect similar to that in the previous series. The addition of 100 ohms increased the cell resistance an average of 361·0 ohms, and the addition of 1,000 increased it an average of

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1261·0 ohms. These increases were 4·49 times larger than those in Table 3 in the case of addition of 100 ohms, and 3·42 times larger in that of 1,000 ohms, if palladium and gold are omitted. The smallest original total resistances were again with the least corrodible, and the largest with the most corrodible metals. The average original resistance was 6·4 times greater, and the average strength of current was less than one-half that in Table 1, whilst the average electromotive force was slightly greater. The resistances of aluminium and of silver were usually large in both tables. The cases of large resistance in this table were greatly magnified in consequence of the circumstance already mentioned, and of the smallness of the currents.

In a paper "On Transfer Resistance in Electrolytic and Voltaic Cells," read before the Royal Society, March 19, 1885, I have shown by experiments that "with an electrolytic cell, using ·02 and ·0022 ampere strengths of current, no manifest difference of the ordinary conduction resistance occurred;" also that "a species of electric resistance, distinct from that of polarisation and of ordinary conduction-resistance, varying greatly in amount in different cases, exists at the surfaces of mutual contact of metals and liquids in electrolytic and voltaic cells;" and further, "that this species of resistance was largely reduced by increasing the strength of the current." From these facts I conclude that all the foregoing instances of total internal resistance consisted not of alterations of ordinary conduction-resistance of the liquid, but of what I have termed "transfer-resistance" at the surfaces of the plates. If, therefore, we deduct from each of the total resistances in the two tables, the ordinary resistance of the liquid, amounting to about 15·5 ohms, the remaining magnitudes represent, within certain limits of variation, "transfer-resistance," and the increases of such resistances by diminished strength of current caused by additional external resistance. According to this, the primary chief cause of the usual weakness of the currents; the much larger original resistances; and of the greater increases of resistance, in Table II. than in Table I., was the large "transfer-resistance" at the platinum negative plate. The smallness of the resistances in the cases in Table I., in which both the positive and negative plates were composed of easily corrodible metals forming readily soluble salts, was due to the small "transfer-resistances" of those metals.

Waltenhofen, Naccari, and Mazzotto have already shown in a limited number of cases that the total internal resistance of a voltaic cell increases with diminished strength of current (Wiedemann's Beiblatter, Vol. V., 1881, pp. 451, 529, 608), but do not appear to have ascertained that this resistance consisted in any degree of an alteration of resistance at the surfaces of the plates; the two latter investigators, however, have observed that in the case of several kinds of voltaic elements, total internal resistance was different when negative plates composed of different metals were employed (*ibid.*, p. 451).

LITERATURE.

Handbuch der Elektrotechnik. By Dr. Erasmus Kittler. [Stuttgart: F. Enke.]

Under this title, which might be translated as "Manual of Electrotechnics," the first half of the first volume of Dr. Kittler's long-expected book has at last made its appearance. The complete work is to consist of two volumes, and in an introductory note the publisher promises that it will be issued at latest within a year from date. The general scope of the book is sufficiently ambitious, inasmuch as it covers nearly all the applications of electricity for lighting purposes, for transmission of power, and for electro-deposition of metals. We reproduce the table of contents given in the publisher's prospectus:—Volume 1: Induction and Lines of Force, Theory, Principles of Continuous Current Machines, Electrical Measurements, with special reference to Continuous Current Machines; Description of various Systems, Theory of Continuous Current Machines, Alternating Current Machines and their Investigation. Volume II: Arc Lamps, Glow Lamps, Photometry, Electric Light Installations, Electric Transmission of Power, Secondary Generators, Accumulators, Application of Electric Machines in Chemical Industries.

From the summary it will be seen that the author proposes to include in his book nearly all the practical applications of electricity, with the exception of telegraphy, telephony, and railway signalling. The first half of Volume I. contains about 300 pages, and treats of the subjects mentioned in the prospectus up to and including electrical measurements. The treatment is rather didactic than analytical or critical, and the reader cannot help being constantly reminded that the author occupies a professor's chair at the Technical school at Darmstadt, and is in the habit of making things plain to an audience of very mixed intellects. A teacher is bound to treat his subjects in a somewhat broader style, to repeat explanations, and to illustrate his meaning with numerous examples, lest some of his pupils may not be able to follow him. With an author this is not required, and although we would not go so far as to say that redundancy of language is a fault in a book, we prefer a terser style, and a more critical treatment, which we almost have a right to expect from the author's high standing in the German scientific world. The first chapter treats of the magnetic field, and of lines of force, which conception is rightly taken as the basis for all future explanations of the phenomena of induction and dynamo electric action. Nothing, however, is said about the magnetic potential and the magnetic shell; this most important factor in the theory of electro-magnets is only mentioned, but not treated at length. The second chapter deals with the induction of currents in linear conductors moving in a magnetic field, and is explained by a profusion of examples and illustrations. All possible combinations of induction between two conductors and a conductor and magnet are given, and the general question of self-induction is treated, but without entering into its theory. In this respect the author contents himself with referring the reader to the works of Helmholtz, Joubert and others. In the third chapter we find a very clear explanation of the currents generated in solid conductors moving in a magnetic field, and we would especially recommend this part of the work to those who have to do with the designing of dynamos. By the many illustrations given they will see at a glance what to avoid in the shape of continuous masses of metal. A short description of the ordinary induction coil and the part played by the condenser in connection with it brings us to the second section of the book, entitled "The Principles of Modern Continuous Current Dynamos." Here we find the usual explanations of the Gramme-Pacinotti and Hefner-Alteneck armatures given at great length, but nothing is said as to how the electromotive force created in any of these armatures can be calculated. The chapter is purely descriptive, the analytical treatment being probably reserved for the theory of continuous current dynamos, which, forming part of the second half of Volume I., will be issued in November next. A few practical hints for the construction of armatures, commutator, and brushes are added. In these the author is hardly explicit enough, and in one or two cases these practical recommendations are nothing more than rule of thumb. To cite only one case, when speaking of the density of current to be allowed in the wires of the armature, and also further on, when speaking of the magnet coils, Dr. Kittler quotes that long-exploded rule of Mr. Uppenborn, according to which in thick wires a current of two amperes, and in thin wires a current of three amperes per square millimetre, may be permitted. Is it possible that the author has never heard of the experiments and theoretical investigations of Prof. Forbes, who more than two years ago has already shown how the density of current in a coil can be determined with due regard to permissible heating? In another place Uppenborn is again quoted—and this time confirmed by no less an authority than Waltenhofen—for a rule of thumb which is not only unscientific but absolutely wrong. We refer to the rule that the exciting power around the field-magnets of a dynamo ought to be proportional to their cross-sectional area, viz., 110 ampere turns per square centimetre. Although the author mentions in a foot note that Ross denies the validity of this rule, he does not throw any further light on this most impor-

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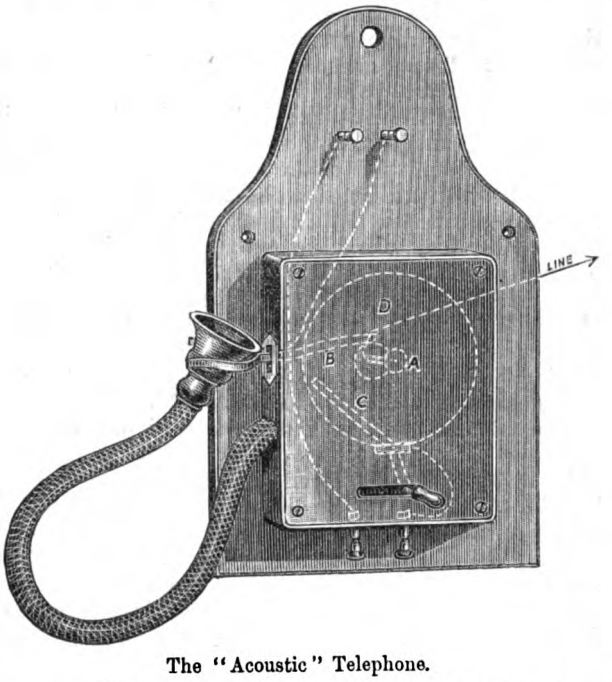
tant question, and the humble student is left to settle as best he may whether Waltenhofen, Uppenborn, or Ross be right. Here, if anywhere, was a case to be taken up by the author in a critical spirit, who might have with advantage devoted a whole chapter to it. If, to make up for such liberality, he had omitted all that he said about the magnetic moment of bar magnets, and the well-known formulæ of Müller, Dub, Jacobi, and others, his book would not have suffered. These can be found in every book yet written on electro-magnets; but has ever anybody been able to utilise them in the practical design of dynamos? We believe not; and the reason is that we do not use straight bars in the construction of dynamos, but horseshoe magnets, and that it is not the magnetic moment of a bar, but the number of lines of force passing between armature and polar surface, which is of importance in a dynamo. This section of the book concludes with an interesting historical sketch of the development of modern dynamos. The third section, treating of absolute measure and the apparatus used in electrical measurements, is by far the best part of Dr. Kittler's book. Those who have visited the author in his laboratory at the Vienna Electrical Exhibition of 1883, and have noted the conscientious care and great accuracy of his measurements, will turn to this part of the book with the expectation of finding a valuable standard work of reference, and they will not be disappointed. In the first place the author gives a complete theory of the tangent galvanometer, inclusive of all the possible sources of error and the method for their elimination. He adds a very useful table of corrections for readings taken with the mirror galvanometer, by which much tedious calculation can be avoided. The sine galvanometer, astatic galvanometer, bifilar suspension, electro-dynamometer, and the absolute electrometer are exhaustively described, as are also the copper and silver voltameters. As regards the latter, we should have expected to find some reference to Lord Rayleigh's latest determination of the electro-chemical equivalent of silver, but the author is quite silent on this important subject. In copper-voltameters he recommends a density of current of 23 to 28 amperes per square foot. Rheostats and resistance boxes, standard cells and differential galvanometers, and their application to the measurements of resistances, are next described. The chapter on Wheatstone's bridge and its numerous modifications will be found particularly instructive. A question of great importance to the practical electrician is that of handy and fairly accurate instruments for the measurement of current and electromotive force. These might have been treated of at greater length. In all, the author devotes only 18 pages to practical volt and ampere-meters, and these few pages are occupied by description pure and simple, without a word of criticism or instruction regarding the use of the instruments. It is to be regretted that the author did not treat of these practical instruments at greater length, and give the reader the benefit of his experience. The book is well printed and profusely illustrated.

MECHANICAL TELEPHONES.

Very many years ago, at the time when youth is reckless, we remember having purchased, for the modest sum of one penny, an apparatus constructed of cardboard, parchment, and string, by means of which fond lovers were supposed to be able to breathe soft nothings in defiance of that cruel element, distance. Whether this was called a telephone or not we do not know; but it was an idea—an old one even then—and cost a penny. That was all that could be said of it. Since that time, however, science has made gigantic strides, and the idea which was evolved doubtless during the antediluvial period has within the last few weeks borne fruit—golden fruit—in, at all events, one quarter. The subject of our illustration shows one application of the idea. It is an apparatus which has been manufactured and sold by Messrs. Weedon and Irish for the last half-dozen years at a moderate sum. Its construction will readily be understood by our readers, it only differing from the toy in the materials used, and in the fact of its possessing a mechanical or electrical call and an ear-piece. We need hardly say that the golden fruit to which we have alluded has not fallen into the hands of this firm, but apparently into those of the promoters of the Mechanical Telephone Company, whose remarkable prospectus will have been perused by many with feelings of admiration for



The "Acoustic" Telephone.

its compilers, not unmixed with some apprehension for the public.

ELECTRIC LIGHTING IN SOMERSETSHIRE.

Ashton Court, near Clifton, the residence of Sir Treville Smyth, has recently been the scene of an extensive installation of the electric light. The following is a sketch of what has been accomplished under the personal management of Mr. S. Sharp:—

Motive Power.—A Crossley twin 6 horse-power gas engine, indicating 28 horse-power, fitted with a self-starter.

Dynamos.—Two Hockhausen shunt-wound machines, by Messrs. Edmunds and Goolden, of Halifax, each giving 105 volts and 85 amperes in external circuit, at 1,100 revolutions.

Accumulators.—Fifty-four of the Electrical Power Storage Company's glass cells, 23 L plates coupled in parallel with the dynamos and lamp circuit to act primarily as a regulator, also to supplement the engine power on special occasions, and to provide light in bed rooms and elsewhere, when the engine is not running. The battery will maintain seventy 20 candle-power lamps for eight or nine hours.

Engine Room Fittings. — The switch-board, a *specialité* of the above-named company, and made by them, is arranged with an accumulator switch, with "off," "on," and ammeter blocks, two dynamo switches, having a similar arrangement, and closing automatically the field before the main circuit, a regulator switch for adding cells as required, and, lastly, a lamp circuit switch. All these being connected to the positive terminals of accumulators and dynamos, there is no possibility of any inexperienced person making a short circuit if interfering with the switches. Voltmeters and ammeters are also affixed to the board. Two large Cunningham magnetic cut-outs (by Woodhouse and Rawson) protect the main cables.

Leads.—The mains, which are carried through the house a distance of 300ft. to the distributing board in the Buckhorn corridor, are calculated at the rate of 625 amperes per square inch, with the maximum number of lamps on, viz., 250.

Main Switch-Board.—Placed in a central position is a large and handsome switch-board, with mahogany case and locked glass door, made by Messrs. Paterson and Cooper. On its massive slate backing are fitted six Eidsforth switches, with as many Cunyngham magnetic cut-outs for the various sections of the house. Attached to the board is a Cardew voltmeter;

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but in order that the engine driver also may know at all times the difference of potential at this distributing board, which is rendered necessary by the fact that the switching on the various rooms will be under the management of the butler, and the number of lamps alight may vary from 1 to 200, the positive and negative bars of the switch-board are put in connection with the engine room voltmeter. The driver then switches on or off one or more cells to maintain a constant pressure at the central point.

Arrangement of Lamps.—The lighting is almost entirely from the ceilings, and so arranged as to ensure an even distribution of light in any part of the rooms. In the hall, drawing room, and boudoir the lamps in the ceiling are arranged symmetrically, according to the designs of Messrs. Jackson and Graham, of London, who have executed the alterations and decorations of these portions. The ceilings of the south entrance, vestibule, and museum are the work of Mr. J. Long, builder, of Bath, under the direction of Major Davis, architect, of the same city. In the south entrance 20 candle-power lamps, with suitable glass shades, hang from the crowns of the richly-carved groined stone roof, and give ·2 candle-power per square foot at a height of 11ft. A pannelled oak ceiling has been erected in the museum; from certain intersections of the moulded ribs fifty-four 20 candle-power lamps are suspended, and yield a light of ·55 candle-power per square foot. The switches are enclosed in boxes let into the stone walls.

Turning from the south entrance to the conservatory, twenty wrought-iron foliated pendants with flowers, to receive the incandescent lamps, give finish to the light iron frame of the roof. These twenty lamps (20 candle-power) are equivalent to ·35 candle-power per square foot. The vestibule, leading into the dining and drawing rooms, has seven lamps as finials to the raised ornamentation of the ceiling, the illumination at the height of 12ft. being ·37 candle-power per square foot. In the drawing room, the panelling being of dark oak, a liberal allowance of light is required. The grouping of the lamps on the ceiling consists of four stars of five Bernstein 50 candle-power lamps, the intermediate spaces being occupied by 10 candle-power lamps. Each star of five has its switch concealed behind a movable panel, the 10 candle-power being governed by one switch.

On the walls of the dining room are four single wall brackets of severe design (from the Anglo-American Brush Electric Light Corporation), with shades, whilst the dining table is illuminated by a pair of screw-armed candelabra, glow lamps taking the place of candles. Under the carpet are let in two of Mr. Tayler's Smith's pin floor connectors. Flexible wires lead from these, through the table to the base of each candelabra, where a similar connector is provided with three pins.

In the study are single and double wall brackets of Faraday and Son. In the boudior a dozen lamps throw down their rays. Wall sockets of the Brush Electric Light Company, to take incandescent lamps, or plugs with flexible wires, are let into the walls of this room, as well as elsewhere, for reading or piano lamps. The brackets in the various rooms are by Messrs. Verity and Sons, of King-street, Covent Garden, and are very elegant.

The upper and lower corridors and landing are fitted with F. and C. Osler's wall brackets and globes. On one staircase hangs a massive chandelier, with four arms, each carrying a duplex oil lamp. The wicks are gone, and carbon filaments have taken their place. Through the glass globes the change is unnoticeable, but the action of a switch behind the panels reveals the secret. A turret staircase and sundry other places also have other lights. Fusible plugs in great number, in addition to the magnetic cut-outs for each section on the main switch-board and the magnetic cut-outs on the main cables, render the installation perfectly safe.

The following is a *resumé* of the lamps:—

	Volts.		Candle-power.
20 Bernstein	50	...	50
160 Anglo-American "Brush"	100	...	20
12 Anglo-American "Brush"	50	...	10
24 Anglo-American "Brush"	25	...	10
32 Woodhouse and Rawson	25	...	10

THE TELEGRAPH CONFERENCE AT BERLIN.

The Tariff Committee meetings have resulted in a recognition of the general principle that what is called the "Grundtaxe," or fixed preliminary charge, on every telegram before the cost of its transmission is assessed according to the number of words, should be abolished or simplified, as well as that terminal dues should be rendered uniform. These decisions, of course, will only form the basis of further discussion by the plenary conference itself, but still they point to the existence of a spirit of conciliation and compromise among the delegates which will probably enable the German Postmaster-General not to go wholly empty-handed away, though it is still regarded as certain that he will not succeed in achieving the acceptance of his proposals in their entirety. His scheme of uniform telegraph dues for all Europe was rejected by a majority of nine to seven.

The following is a list of the delegates of the various Governments represented at the Conference:—

Country.	*Delegates.*
Germany	Dr. von Stephan (Secretary of State); Mr. Hake (Director of the Second Division of the Department of Posts); Mr. Scheffler, Mr. Fritsch, and Mr. Le Sage.
Austria-Hungary and Bosnia-Herzegovina:—	
Austria	Dr. Brunner de Wattenwyl, Mr. Laurenz J. Wolschitz, and Dr. Charles Benesch (acting secretary to the Minister of Posts and Telegraphs).
Hungary	Mr. Koller de Granzow (Director-General of Telegraphs), and Mr. Francois Mokry.
Bosnia-Herzegovina	Lieut.-Colonel Oscar Parmann.
Belgium	Mr. F. Delarge (Engineer-in-Chief and Director of Telegraphs).
Brazil	Baron de Gapanema (Director-General of the Imperial Telegraphs).
Bulgaria	Mr. Ivanoff (Director-General of Posts and Telegraphs).
Denmark	Mr. Höncke (Director of Telegraphs), and Mr. C. C. Lund.
Egypt	Mr. Floyer (Inspector-General of Telegraphs), and Iskandar Bey Fahmy.
Spain	Mr. Aquilino Herce (Director-General of Posts and Telegraphs), and Mr. Vicente Coromina y Marcellan.
France	Mr. Fribourg (Director of Posts and Telegraphs), Mr. Lorin, and Mr. Brunot.
Cochin China	Mr. Brunot.
Great Britain	Mr. Patey (third secretary to the Post Office), Mr. H. C. Fischer (controller of the Central Telegraph Station), & Mr. Benton.
British India	Col. Bateman-Champain, R.E. (Director-in-Chief of Indo-European Telegraphs), and Mr. C. H. Reynolds.
British Colonies:—	
Victoria, Australia	Not represented.
South Australia	Mr. C. Todd (Postmaster-General and Superintendent of Telegraphs).
New Zealand	Not represented.
Tasmania	Mr John Henniker Heaton.
Cape of Good Hope	Not represented.
New South Wales	Mr. E. C. Cracknell.
Greece	Mr. Durutti.
Italy	Commander E. D'Amigo (Director-General of Telegraphs), and Chevalier Berliri (assistant).
Japan	Mr. Tadasuke Ishie (Director-General of Telegraphs), Mr. Takémoura (secretary), and Mr. Yoshida (secretary).
Luxembourg	Mr. Mongenast (chief of the Department of Posts and Telegraphs).

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Country.	*Delegates.*
Montenegro	Dr. Brunner de Wattenwyl and Mr. Laurenz J. Wolschitz.
Norway	Mr. C. T. Nielson (Director-in-Chief of Telegraphs) and Mr. J. U. F. Bugge (assistant inspector of Telegraphs).
Holland and Dependencies	Mr. M. J. P. Hofstede (Director-General of Posts & Telegraphs).
Persia	Colonel Smith.
Portugal	Mr. Guilhermino Augusto de Barros (Director-General of Posts, Telegraphs, and Lighthouses).
Roumania	Colonel Pastia (Director-General of Posts and Telegraphs); and Mr. J. Jacovesco.
Russia	Mr. De Besack (Director-General of Posts and Telegraphs); Major General Ussow, & Mr. de Rossi.
Servia	Not represented.
Siam	H.H. Prince Prisdang, Mr. Luang Nai Tej (First Secretary of the Legation); and Mr. Wilberforce Wyke (Secretary of Legation)
Sweden	Mr. D. Nordlander (Director-General of Telegraphs); and Mr. H. E. Uddenberg.
Switzerland	Mr. Frey (director of Telegraphs).
Turkey	Her Ambassador at Berlin.
Bureau International	Mr. Curchod (director of the International Bureau), Mr. Eschbaecher (secretary), Mr. Neumann, and Mr. Linz.

The following is a complete list of delegates representing the cable companies :—

Company.	*Delegates.*
Anglo-American	Mr. Henry Weaver and M. Jules Despecher (representative of the company in Paris).
Black Sea	Mr. John Pender, M.P. (chairman), and Mr. Lewis Wells.
Brazilian Submarine	Mr. Thomas Fuller (managing director).
Central and South American	Not represented.
Commercial Cable	Not represented.
Compagnie Française	Mr. Henry Weaver.
Cuba Submarine	Not represented.
Direct Spanish	Sir James Anderson (chairman) and Mr. C. Gerhardi (manager).
Direct United States	Mr. John Pender, M.P. (chairman); Mr. J. W. Fuller, secretary and traffic manager).
Eastern	Mr. John Pender, M.P. (chairman); Sir James Anderson (managing director); Mr. Lewis Wells; M. Jules Despecher (company's agent in Paris), and Mr. Hibberdine (assistant).
Eastern Extension, Australasia, and China	Mr. John Pender, M.P. (chairman); Mr. Lewis Wells; M. Jules Despecher, and Mr. J. E. Hesse.
Eastern and South African	Mr. John Pender, M.P. (chairman); Sir James Anderson (managing director); and Mr. Lewis Wells.
German Union Telegraph and Trust	Dr. Lasard (director); Mr. Steinhardt, and Mr. Payton (secretary).
Great Northern	Capt. E. Suenson, of Copenhagen (managing director); Capt. W. de Hedemann (company's agent in St. Petersburg); and Mr. F. C. C. Nielsen (manager of London office).
Indo-European	Mr. W. Andrews (managing director); Mr. F. Moll (secretary), and Dr. Werner Siemens (representative of the company in Berlin).
London Platino-Brazilian	Not represented.
Spanish National Submarine	Count Th. d'Oksza (director) and M. Lucas Mariano de Tornos (company's agent in Paris).
Submarine	Sir Julian Goldsmid, Bart. (chairman); Mr. G. von Bunsen.
West Coast of America	Mr. Robinson Kendal (chairman).
Western Union	Mr. Henry Weaver.
West India and Panama	Mr. W. Andrews and Mr. Henry Weaver.
Western and Brazilian	Major A. Wood (managing director).

UNIFORMITY OF CHARGE FOR EUROPEAN TELEGRAMS.

The proposal of Germany that there should be one uniform word-rate for European telegrams arises naturally out of the past history of international telegraphy, and is almost suggested by the very existence of such a Congress as that which is now meeting. The object of a conference between different States on telegraphic matters is to facilitate international communication and to harmonise the principles upon which it is conducted. The adoption of a common code, and of uniform principles of telegraphic working, the settlement of detailed rules to be observed by every State, as to the mode of counting and charging for the contents of a message and the character of the services to be performed for the public, are all important applications of the principle of uniformity. And former Conventions have gone further than this. Some years ago it was agreed that the charges made by each State for messages originating in or destined for any part of its dominions should be the same without reference to particular locality. More recently the principle of a word-rate throughout the telegraphic world was adopted. With this basis to start from, and with the analogy of the uniform postal charge throughout Europe, it would have been surprising if the suggestion that there should also be one European word rate for telegrams had not been made, and there will be a general, though we think unreasonable, feeling of disappointment at the announcement that the Congress is not disposed to receive it favourably. There is a second branch of Dr. von Stephan's proposal which is quite distinct from the first, but which, if possible, is still more natural. Under the Postal Union arrangements all postage is prepaid, and each country keeps its own receipts, the existence of elaborate accounts being thus obviated. Under the Telegraph Conventions, on the contrary, each country accounts to the other for a portion of the charge upon each telegram. Thus, if a telegram is sent from London to Paris, Great Britain accounts to France for the charge which France has agreed to as her due on a telegram destined for her territory. Dr. von Stephan proposes that the principle of the Postal Union should be applied to telegraphy, and that each country should keep all payments it receives for telegrams despatched within its territory, paying all expenses of transmission. Although the senders of telegrams are not interested in this part of the question, it is obvious that it has an important bearing upon the effect of the whole scheme upon the revenues of the several States, and must consequently influence their representatives in the discussion at Berlin.

Unfortunately for the attainment of a uniform rate, telegraphic arrangements are complicated by the fact that State Governments are not the only agencies occupied in transmitting telegrams. There are no private posts in Europe, but there are private telegraph companies. The Continental Powers, like England, send the telegrams of their subjects within their own dominions, and if all telegrams passed only over land lines the States would have a free hand in telegraphic legislation. But submarine cables play an important part in European telegraphy, and the longer cables are nearly all in the hands of private companies. In laying submarine cables official caution followed private enterprise at a respectful distance, and no great amount of public money has been sunk in this species of investment. The cable companies have spent millions in linking together distant countries, and they naturally desire to reap the fruits of their venture and to pay a reasonable dividend to their shareholders. A public administration may be prepared to lose, or at least to risk, something over its telegraphs for the purpose of stimulating commerce and adding to the amenities of life, but a private company exists to earn money for its constituents. Hence the cable companies are naturally found on the side of caution when projects of telegraph reform are under discussion. They have expensive plant to keep up, and they protest that they cannot make sweeping reductions without being brought face to face with bankruptcy and ruin. The Continental nations are but slightly interested in the fate of the cable companies. A large number of foreign telegrams can be sent entirely overland. Germany, for example, touches almost every other Continental nation, and is cut off by the sea from Great Britain

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and the Scandinavian Peninsula only. On the other hand, neither Germans nor any other Continental people have invested any appreciable amount of capital in cable enterprise. Great Britain is very differently situated. She cannot be reached except by the sea, and though the British Government is largely interested in the most important and direct communications with the Continent, many cables which are entirely in private hands leave our shores; and nearly all the money sunk in submarine telegraphs has been found by the people of this country. While, therefore, zeal for a uniform low-priced telegram is a comparatively cheap virtue on the part of Germany, England is compelled to pause and count the cost before she can give free rein to the same generous impulse.

It will, of course, be said that private interests should not stand in the way of public good, that those who invested in submarine cables did so for their own profit, and have no more right than Egyptian bondholders to the services of the State to save their pockets. It is hardly, however, State assistance which the companies ask; what they deprecate is active competition at the hands of a concert of European States. Let us consider what would happen if England overlooked entirely the views of the companies and embraced the German proposal. The companies are not represented on the Telegraph Congress. They are allowed to be present and to follow the discussions, but have no votes. The proposal for a uniform rate might therefore be carried notwithstanding their protests. The rate proposed by Dr. von Stephan consists of a fixed tax of 50 centimes for every message and a word-rate of 20 centimes per word, with an additional charge not to exceed 10 centimes per word, when correspondence is transmitted over a submarine cable. Thus messages from Great Britain to Spain, for example, would be charged at the maximum rate of 30 centimes or 3d. per word with an addition of 50 centimes or 5d. for each message. The present rate to Spain by line of the Direct Spanish Company, which has a cable from the Lizard to a point near Bilbao, and by that of the Eastern Company, whose line runs from Porthcurno in Cornwall to Vigo, as well as by the overland route through France, is 6d. The Congress has no power to bind the Direct Spanish or the Eastern Company to lower its charges. The only mode in which it could enforce its reduced rate of a trifle over 3d. would be by underselling the companies by means of the overland route. As far as this country is concerned there would be an initial difficulty in arranging with the companies who are interested in the direct cables to France and Belgium. This could only be done if these companies opposed the reduction, as they certainly would, by offering them some kind of compensation. But it would be impossible for the Government of this country, after compensating one private company for an apprehended loss of income, to be a party to an active competition with other private companies, with the avowed object of forcing a similar loss upon them. The demand for compensation on the part of the Direct Spanish and Eastern Companies would in the case we have put be irresistible, and a similar result would ensue in the case of other companies. Even if the Government were deaf to all appeals on the ground of fairness as between one company and another, there are reasons why it would be impolitic to destroy cable communications with distant parts of Europe. Such communications have before now been highly useful both to the Government and commerce of this country when overland routes were interrupted, and it is impossible to tell when such a state of things may recur. Moreover, our communications with the East are facilitated and guaranteed by the existence of sea lines skirting the coast of Europe, and it is not likely that the country would look favourably on any policy which tended to impair in any degree our telegraphic connection with India. Thus the Government would inevitably be landed, sooner or later, in the acquisition of the undertakings of all the cable companies so far as regards European communications; and the taxpayer would in all probability pay a great deal more than the property of the companies was worth, as he did on the purchase of the inland telegraphs, and perhaps be called upon to work a losing undertaking into the bargain.

It may, of course, be argued that it is from mere timidity that the cable companies are deterred from embracing a proposal which, by increasing their business, would, in the long run, give them a large profit. But there is no magic in uniformity of charge. If the actual expense of sending a telegram from London to Spain is more than the sum charged for the work, the result must be a loss; and the fact that the same charge yields a handsome profit on the despatch of a telegram between Berlin and Vienna will not make the loss any the lighter. The fact is the advantages of uniformity of charge only exist where an undertaking is in one hand, and the logical sequence to Dr. von Stephan's proposal would be that all the European States and cable companies should make a common purse. But so far is he from recommending this that he proposes to abolish all accounts and leave each country to keep its own receipts. One can hardly expect a dividend-paying company to embrace a proposal in blind faith that somehow or other it is to be for the benefit, although all considerations of pounds, shillings, and pence lead to an opposite conclusion.

There are other considerations bearing upon the German proposition. The Government of this country is itself interested in communications with the Continent, and would probably be a loser by the reduction of rates, though it would gain by the retention of all moneys paid in this country for the transmission of telegrams, since Great Britain sends more telegrams than it receives. To other countries the proposed abolition of accounts would be prejudicial, and hence it is that Dr. von Stephan's proposal meets with opposition from inland States. But for this country the main consideration must be the effect of the uniform rate upon the interests of the cable companies, and the consequences that any serious attack upon them must entail upon the relations of the Government to cable enterprise. Attractive as the German proposal is at first sight, it is probable that the interests of the public will be better served by a less heroic policy, which, while duly regarding the interests of those who have acted as pioneers in oceanic telegraphy, shall use the resources and influence of the great European States to enforce a continuous improvement in the conditions of international intercourse.—*The Times.*

LEGAL.

The Electro-Amalgamator Company (Limited).

In the Chancery Division, on Wednesday, before Mr. Justice A. L. Smith, vacation judge, an application was made on behalf of Mr. F. Horner Lyell, a creditor and shareholder, for a winding-up order. Counsel for the petitioner said the company had requested that the petition should stand over, and he asked that it should stand over for a fortnight.

The JUDGE: Let it stand over for a month. Then my brother Mathew will be here [laughter].

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Aug. 19.			Business Done Week Ending Aug. 19. Highest.		Lowest.
Anglo-American	29½,	30½	.....	29½	.....	28¾
Do. Preferred	50½,	51½	.....	51	.....	49½
Do. Deferred	8½,	8¾	.....	8½	.....	8
Brazilian Submarine	11½,	11½	.....	11 3-16	.....	11⅛
Cuba	12,	12½	.....	12 1-16	.....	—
Do. Preference	18,	19	.....	18	.....	—
Direct Spanish	1½,	2	.....	—	.....	—
Do. Preference	12,	12½	.....	—	.....	—
Direct United States Cable	8¾,	9	.....	9½	.....	8¾
Eastern Telegraph	11 11-16	11 13-16	.....	11¾	.....	11⅝
Do. 6 per Cent. Preference	13½,	13¾	.....	13½	.....	13
Do. 5 per Cent. Debentures, 1899	105,	108	.....	—	.....	—
Eastern Extension	13,	13½	.....	13¼	.....	13
German Union	9½,	9¾	.....	9½	.....	—
Globe Telegraph and Trust	6 15-16	7 1-16	.....	7¼	.....	6 15-16
Do. Preference	12¾,	13½	.....	13	.....	12 13-16
Great Northern	13½,	14½	.....	14½	.....	14
Indo-European	31,	32	.....	31	.....	—
Reuter's	7½,	8	.....	—	.....	—
Submarine	180	190	.....	—	.....	—
West India and Panama	13-16	15-16	.....	13-16	.....	¾
Do. 1st Preference	8½,	8¾	.....	8 5-16	.....	—
Western Brazilian	6½,	6¾	.....	6 5-16	.....	6 1-16
Western Union 7 per Cent. 1st Mortgage	120,	124	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	103,	105	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	12/6	13/6	.....	⅝	.....	—
Oriental	3/6	4/6	.....	—	.....	—
United Telephone	11½,	11¾	.....	11 9-16	.....	1 ¼

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1⅝,	1¾	.....	1¾	.....	—
Do. (fully paid)	2½,	3¼	.....	3¼	.....	—
Hammond Light (£3 15s. paid)	1-16	3-16	.....	—	.....	—
Swan	⅛,	¼	.....	—	.....	—
Maxim-Weston	⅛,	¼	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	37½,	37¾	.....	38¼	.....	37¼
India Rubber, Gutta Percha, and Telegraph Works	24,	25	.....	24¼	.....	24¼

TRAFFIC RECEIPTS FOR JULY, 1885.

Companies.	July, 1885.	July, 1884.	Increase.	Decrease.
Cuba Submarine	2,500	3,219	—	719
Direct Spanish Telegraph	1,260	1,501	—	241
Eastern Extension	46,099	40,870	5,229	—
Eastern Telegraph	48,081	50,072	—	1,991
Great Northern	25,200	—	—	—
West Coast of America	3,325	—	—	—

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NOTES.

NOTICE OF INTERRUPTION.—The cable between Fao and Bushire is interrupted.

LONG DISTANCE TELEPHONY IN EGYPT.—The Government has authorised the establishment of a telephone between Cairo and Alexandria.

PERSONAL.—The Calcutta *Englishman* understands that Colonel Grierson will shortly go to Calcutta as Examiner of Telegraph Accounts.

INTERESTING.—M. Lazare Weiller, it is said, is about to make known the results of his experiments upon the electric conductivity of pure metals and of alloys.

AN ELECTRIC SEWING MACHINE COMPANY.—A company is being formed in America to run sewing machines by electricity on the Stockwell system, which is being now so successfully used in Philadelphia.

VOLK'S ELECTRIC RAILWAY.—Mr. Volk, whose electric railway is now laid at Brighton, has been invited to submit his scheme before the Southport Corporation with a view to its introduction on the Southport shore.

NEW TELEGRAPH OFFICE IN CHINA.—The Chinese Administration announce the opening of a new telegraph office at Hoihow. The rates are 1f. 25c. per word for local telegrams, and 2f. per word for foreign messages.

THE TELEPHONE IN FRANCE.—At Troyes there are 126 subscribers to the exchange, and at Saint Quentin 62. At Boulogne not much has as yet been done, but there is every probability of an extension being made at an early date.

THE ELECTRIC LIGHT IN MINES.—A new shaft is being sunk, and large additions to the plant are being made, at the Backworth and Ashington Collieries, Newcastle, one noticeable feature being the application of the electric light on the Maxim-Weston principle.

THE ALTERNATIVE CABLE TO THE CAPE.—Although the project of establishing an alternative cable to the Cape has for a long time remained in abeyance, there are rumours that a definitive decision favourable to the enterprise has at last been come to. It may be that by this time next year the cable will be in working order.

LAYING OF A DUPLICATE CABLE.—The Eastern Telegraph Company announce the laying of the duplicate cable between Zanzibar and Mozambique, by the ss. "Seine," belonging to the Telegraph Construction and Maintenance Company. The line has been laid with the view of improving the service and to guard against future interruptions of communication with South Africa.

TELEGRAPHIC COMMUNICATION WITH THE TORY ISLANDS.—About 100 gentlemen, comprising representatives of Glasgow, Liverpool, Belfast, and Londonderry shipowners, visited Tory Islands recently, and, having examined the Island, passed resolutions in favour of establishing telegraphic communication between the island and mainland, and urging the Government to afford this communication.

NEW TELEPHONE EXCHANGE.—Mr. H. C. Grahame, an energetic gentleman connected with the South of England Telephone Company, has just opened an exchange at Northampton, with a list of 20 subscribers and four private lines. As Mr. Grahame has succeeded so far in the short space of time, some three months, he has been in Northampton, it may safely be predicted that the exchange, ere long, will be in a fairly prosperous condition.

CATALOGUES RECEIVED.—Messrs. Cordner, Allen, and Co. issue a well-illustrated and comprehensive catalogue describing the various electrical apparatus manufactured by them. The catalogue also contains some useful tables relating to electric light cables and wires, as well as a copper wire resistance table, &c. Messrs. Harvey and Peak (successors to W. Ladd and Co.) have also issued a revised catalogue of electrical and mathematical apparatus.

SALES OF PLANT.—Particulars will be found in our advertisement columns of electrical and mechanical plant and stores about to be sold by public auction. The electrical plant consists of Ferranti, Brush, Gramme, and other dynamos; exciters, arc and incandescent lamps, installation fittings, cables, manufacturing plant, &c., the same being the property of the Hammond Electric Light and Power Supply Company, now in liquidation. A quantity of similar stores are also to be similarly disposed of by Messrs. Fryer and Son, at 252, Goswell-road, on the 1st and 2nd proximo.

TRAIN LIGHTING IN INDIA.—Mr. Winter, the telegraph engineer of the Madras Railway, has concluded certain very interesting experiments in connection with the lighting of trains by electricity. The batteries are to be worked by the engine of the train itself, but the difficulty was to keep the batteries working when the train stopped. After many patient enterprising experiments, Mr. Winter succeeded in constructing storage batteries in the train. When the latter stops, the connecting wire is hitched on to the storage batteries and the light maintained perfect during the stoppage.

MRS. GAMP AT SEA!—Captain Campbell, master of the steamer "Princess Beatrice," which runs between Larne and Stranraer, has related at Belfast a curious incident which has occurred on board this week. During a voyage it appears that the man at the wheel noticed the compass was so disturbed by something that he could not keep the vessel on her course. He reported the matter to the mate; and the captain, on making an investigation, discovered that the "gamp" of one of the passengers acted as a "very powerful magnet," and thus diverted the needle. And yet people will persist in carrying umbrellas!

GAIETIES IN BERLIN.—Perhaps the most sumptuous entertainment to which the delegates of the Telegraph Conference in Berlin have hitherto been treated was a garden party given on Saturday evening in their honour by Herr Geheimrath (brother of the late Sir William) and Frau Siemens, at their residence in Charlottenburg. Their drawing rooms and lawns, which were all beautifully illuminated with the electric light, were crowded with about 300 of the chief social and scientific celebrities of the capital, and the hospitality offered them was worthy of such a German prince of science as the brother of Sir William Siemens.

THE EXPERIMENTS AT CREIL.—According to *Le Bulletin International des Téléphones*, M. Marcel Deprez is perfectly satisfied with an initial E.M.F. of 4,500 volts. This reduction of course necessitates a proportional decrease in the quantity of energy transmitted to Paris; without that, to produce 200 h.-p. (French), or 147,000 watts, with 4,500 volts, the current strength would have to be 32·7 amperes, and the loss upon the line, of which the resistance is 100 ohms, would amount to 107,000 watts, or 145 h.-p. That would leave a maximum of 55 h.-p. disposable, neglecting the internal resistances of the generating and receiving machines.

TWO TELEGRAPHISTS DROWNED.—The bodies of Robert G. Cary and Herbert J. Steer, who were drowned by the upsetting of a boat in Southampton Water on Sunday evening, have been recovered close to the scene of the accident. The

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inquest was opened at Elling, Lieutenant Jones, R.E., attending from Aldershot, the two deceased men belonging to his company. It seems they were engaged at Southampton on telegraph duty, and on Sunday afternoon went out in a boat with a fellow lodger named Smallbone, a railway guard. As they were changing seats the boat capsized, and the deceased were never seen afterwards. Smallbone was saved by some men who had pulled to the spot. The inquest was adjourned.

NEW PUBLICATIONS.—The syllabus of day and evening classes at the Mason Science College, Birmingham, contains, in addition to the usual list of the officers of the college, &c., the rules and regulations to be observed by students and which govern admissions to the college. A description of the various scholarships open for competition is also given, together with a table of classes, the dates of examination for degrees of the University of London, a note upon Government aid towards the instruction of science teachers, and other useful information. The Durham College of Science (Newcastle-on-Tyne) Calendar is a similar publication, containing, however, in addition to the information mentioned in the foregoing, examination papers of a much more extended nature.

LANCASHIRE AND CHESHIRE TELEPHONE COMPANY.—The fourth annual meeting of the shareholders of the Lancashire and Cheshire Telephone Company was recently held in Manchester. In moving the adoption of the report and statement of accounts the chairman (Mr. Charles Moseley) spoke in hopeful terms of the progress which the company is making and its prospects for the future. The new arrangement with the Post Office had greatly facilitated their movements, and negotiations were being made, or were contemplated, for establishing call offices at the post offices and railway stations throughout the district. The report was adopted, and a dividend at the rate of 7 per cent. was declared. It was also resolved to increase the capital by the issue of 30,000 new shares of £1 each.

THE ELECTRIC LIGHT FOR WAR SHIPS.—The Lords of the Admiralty have given to Messrs. Siemens Brothers and Co. the order to light the following ironclads, viz. :—The twin screw turret ship "Edinburgh," of 9,150 tons and 7,520 horse-power; the barbette ships "Warspite" and "Impérieuse," each of 7,390 tons and 8,000 horse-power; the "Collingwood," barbette ship, of 9,150 tons and 9,570 horse-power; and the "Rodney," barbette ship, of 9,700 tons and 9,500 horse-power. These vessels are to be lighted throughout with incandescent lights, and are to be fitted in addition with search lights for fighting purposes. The current will in each ship be supplied by three independent dynamos, each coupled direct to a Willans central-valve compound engine, capable of indicating about 35 horse-power at a speed of 400 revolutions per minute.

THE ELECTRIC LIGHT IN PORTUGAL.—Although the electric light is making its way steadily in every other European country, Portugal obstinately refuses to avail herself of one of the greatest blessings of modern civilisation. Her cafés, her hotels, and promenades are dim with bad gas, and redolent of the odours which invariably attend the injudicious use of that source of semi-darkness. In that little kingdom there is but one lamp (a Siemens arc), and one dynamo. These are installed in the ancient Tower of Belem, on the Tagus, and serve not only to light up the entrance to the river, but to enable a sharp watch to be kept upon the vessels in quarantine, and the Lazaretto upon the left bank. Electricity against disease. We can only hope that Portugal will further recognise the great sanitary and other advantages attending the use of this luminant.

GALLANT RESCUE BY A POSTAL TELEGRAPH CLERK.—According to a contemporary, on Saturday afternoon last a young child, whilst playing at the deep end of the ornamental water in St. James's Park, fell into the water, and soon after disappeared from sight; although a number of men were near the spot, yet no one ventured to render assistance. A postal telegraph clerk, named William Berriff, shortly afterwards arrived on the scene, and on hearing the circumstances, quietly put down his bag, and dived into the water with all his clothes on. He succeeded in bringing the child to shore, and, with some difficulty, the apparently lifeless child was restored to animation. The gallant fellow, after assisting to restore the infant to life, quietly took his departure, and turned up at his office near by. His colleagues were greatly surprised at his arrival in a thoroughly drenched condition.

THE ELECTRIC LIGHT IN HOSPITALS.—The Edison Company, which lately placed a plant at the Wauwatosa insane asylum, near Milwaukee, in accordance with a request from the authorities there, has introduced a novel arrangement for regulating the light of the lamps in the hospital and other places where a full illumination is not constantly needed. The desired result is effected in a very simple manner. The apparatus consists of five resistance coils of varying strength, which are cut in or out of the lamp circuit by means of a switch. A sixth contact cuts out the light entirely. The whole is mounted upon a small board which can be fastened on the wall or wainscoting, and is about 6 by 8 inches. The coils are enclosed in tin, and outside this is a wire cloth grating. It is also proposed to use these as heaters for the patients, by attaching them by a flexible cord, so that they may be utilised in a bed, chair, or as a footstool.

THE NEW JENNEY DYNAMO.—In the new Jenney dynamo the manner of connecting the armature coils with the commutator sections is somewhat novel. In order to provide a connection between the two which shall permit of their easy separation, the ends of the commutator sections are slotted in such a way that the wires from the armature coils can be forced into the slots of the sections; they are then held therein by a band, formed by winding a hemp cord on the outside of the connecting wires. This band serves to keep the wires in place, and to prevent their being broken by centrifugal force, and also serves to prevent copper dust or the like from entering the inside of the armature, which would short-circuit the coils. When it is desirable to remove any of the wires, the hemp cord is unwound, and they can be slipped out of the commutator sections without bending or injuring them in any way.

ELECTRIC INVENTIONS IN AMERICA.—During the quarter ending March 31st of the present year about 226 patents have been granted in the United States for electrical inventions. Amongst these Louis A. Berthon, Paris, claims one, "telephonic circuit and apparatus;" Brush three, viz., two "armatures for dynamos," and an "arc lamp;" Daft one, "electric railway;" Edison one, "chemical stock-quotation telegraph;" Hockhausen three, "automatic cut out, arc lamp, and focussing arc lamps;" T. D. Lockwood two, "battery, telephone, and electric signalling circuit;" W. M. Mordey one, "dynamo;" Philippart, of Paris, one, "secondary battery;" Reckenzaun one, "dynamo and motor;" Holroyd Smith one, "electric railway system and car;" Sprague three, "regulator for electro-dynamic motors, electro-dynamic motor, electrical indicator;" and, lastly, Weston four, *i.e.*, electric lamp fixture, manufacture of incandescents, dynamo, and system of generating and regulating electric currents."

SERVICES OF RESERVE TELEGRAPHISTS IN THE EASTERN SOUDAN.—The Postmaster-General has directed that the following extract from a report of the late Acting Director of

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Telegraphs at Suakin, as regards the reserve men from the 24th Middlesex (Post Office) Volunteers employed with the Royal Engineers in the recent operations in the Eastern Soudan, be published for the general information of Officers of the Department:—"As telegraph operators these men are of the highest efficiency. As regards their conduct I can only say that on no occasion during the four months they were under my command had I the slightest cause to find fault. I found them at all times, under very trying circumstances, ready and willing to carry out orders, and to take their share in the roughest work—including the care of horses on the picket line, to which of course they were wholly unaccustomed—and I would be much obliged if you would bring to the notice of H.M. Postmaster-General the creditable way in which they conducted themselves."

THE BRITISH ARCHÆOLOGICAL ASSOCIATION AT BRIGHTON—The Mayor's *conversazione* was marked by the illumination of the Old Steine enclosures, the work being carried out entirely under the direction, and at the expense, of Mr. Volk, the electrician, who brought to his aid electricity, gas, and oil, and thus provided in various parts of the enclosures a very great attraction for the inhabitants. Gas standards were erected, and the jets were enclosed in pink-coloured globes, which cast a soft and pleasant light around. A large number of glow-worm lamps, of almost all conceivable colours, were scattered as it were about the grounds and twined around the fountain. The general effect of the illuminations was exceedingly bright and gay, and thousands of persons who visited the Steine to witness them were delighted with what they saw. At one period of the evening the fountain was put into play and the electric light thrown upon it from a powerful lamp at No. 1, Marine-parade, but the diffusion of the light could hardly be called a success. This was owing to the fact that the lamp could not be placed nearer, the rays being too greatly dispersed. Otherwise the arrangements were in every way satisfactory, and reflected great credit upon Mr. Volk.

THE ELECTRIC LIGHT IN CORN MILLS.—Messrs. Rishworth Brothers, corn millers, York-street, Leeds, have introduced the incandescent electric light into their mill, and the whole place is now illuminated by this means. The installation consists of 97 16 candle-power Edison-Swan lamps, the current for which is supplied by one of Crompton's patent wrought-iron dynamo machines of compound self-regulating type. The power is taken from their mill engine for the present by means of a belt. Near the dynamo are the switches for the main circuits, by means of which the various rooms are lighted or extinguished at pleasure. Here also are the cut-outs. In each room there is in addition one or two auxiliary switches for turning out such lights as are not regularly required. On each floor there is an ingenious arrangement in the shape of movable lanterns, provided for inspecting the interior of the various machines and gearing, and for use in places where a naked light or even a covered oil lamp would be dangerous. The lights in the offices are provided with suitable Venetian shades. The work has been done by Mr. Wilson Hartnell, M.I.M.E., consulting engineer, of Leeds.—The City Corn Mills, belonging to Mr. Alexander M'Dougal, Manchester, have also just been lighted with the incandescent light.

THE ELECTRIC LIGHT AND PHOTOGRAPHY.—Experiments were made on the 20th inst. at the Royal Gun Factories in the Royal Arsenal, Woolwich, in order to test the application of a new electric lamp, designed for making examinations and photographs of gun interiors. The system of scrutinising the bores of guns by means of electricity has only been a short time in vogue, and has proved of great value, but the want of an electric dynamo has prevented its general adoption at many places where it would have been of considerable use, and the authorities have now taken up readily a portable battery for the purpose of supplying the place of a dynamo in such cases. The battery, without being necessarily powerful, is chiefly serviceable on account of its constancy, as it can maintain a light of unerring brilliancy for a period of ten hours if requisite, and then enable the examiners to make their inspections with all the leisure they may desire. The experiment was to try the battery and a dynamo in competition. Two 8in. guns were placed side by side in the new boring mills, and photographs were taken of their interiors by both processes, the results, as far as could be judged by a cursory view, being equally satisfactory. Col. Tarleton, Royal Artillery, Assistant Superintendent of the Gun Factories, was present; the electric apparatus was directed by Mr. Angus, and Mr. C. O. Brown, of the Chemical Department, superintended the photography. In future it may be expected that reports of damaged guns sent in from distant stations will be accompanied by photographs, both internal and external.

A CURIOUS PHENOMENON.—A contemporary is informed that, at about midnight on July 29, a remarkable phenomenon was seen at Jönköping, Sweden, over Lake Wettern. A strong luminosity was suddenly seen in the north, where some very peculiar clouds—looking like icebergs—were observed almost to touch the water. From these clouds electrical discharges continually proceeded, imparting to them a bluish, phosphorescent light, somewhat ruddy near the water and intensely yellow at their sides. It seemed like a constant discharge of fireworks from the lake. It was remarkable that the light—as is generally the case with an electrical discharge in the atmosphere—did not assume the form of bunches of streamers, but at one time flared up intensely and at others formed narrow bands across the clouds. Above the latter there was a faint bluish reflection. The lake lay as calm as a mirror, and though an optical illusion was uncommon in these parts, the western shore seemed close to the town, while the eastern disappeared in the clouds. Except the electricity-laden clouds in the north the sky was clear, stars shone, and the full moon was bright. Below the latter the sky seemed faintly red, compared with the intense electric light. At Katrincholm the same phenomenon occurred in the north east. Here an intense glare was seen above a cloud, assuming the appearance of two gigantic lustrous trees, which remained thus for half an hour, when it changed into a variety of forms. There was no noise accompanying the phenomenon, which lasted in both places for about one hour. It is not probable that the phenomenon could have been of auroral nature on account of the brightness under a full moon.

THE ELECTRIC LIGHT FOR STEAMSHIPS.—The "Aquidaban," the new ironclad recently built for the Brazilian Government by Messrs. Samuda Brothers, and now lying in Millwall Docks, was completely lighted up by electricity on the evening of the 20th inst. Any one who has explored the depths of an ironclad can readily conceive the value of the incandescent lamps in such subaqueous regions In the admiral's rooms and the officers' quarters they are a veritable luxury; while for all work on deck, including the loading or unloading of stores, their capability of being grouped under a shade and used as a pendant light at any height or depth renders them of the highest utility. All these advantages are obviously obtained to the full in the arrangement of the 220 incandescent lamps with which

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Messrs. R. E. Crompton and Co. have supplied the "Aquidaban." But for the purposes of an ironclad another adaptation of the electric light is of paramount importance, and Messrs. Crompton and Co., have therefore also fitted this vessel with two great search-lights—arc lights of 25,000 candle-power nominally, but of greatly magnified intensity when their beam is concentrated by the mirror arrangements of the lamp and projected, as it may be, for long distances on either side of the ship. One of those powerful lights is placed aft, and the other in an elevated position in front of the bridge. By a special invention the mirrors of the huge projectors, as well as the whole of the incandescent lamps, are so hung as to minimise the risks of fracture from the concussion caused by the firing of the heavy guns in the turrets. The dynamos driven by the compound Willans engine work with surprising gentleness and freedom from vibration. The trial run of the light was, it need scarcely be said, very successful.

THE ACCIDENT AT EARL'S COURT.—On the occasion of the Board of Trade inquiry, on Wednesday last, into the circumstances attending the railway collision which occurred on Sunday afternoon last near Earl's Court, John Brazier, who has been a signalman at Warwick-road box for two years, said he was alone in his cabin when the collision occurred. The down home signals were not easily seen from the cabin, but they were electrically repeated there. Everything was in good condition before the collision. The last train from West Brompton previous to the collision was the one due at Earl's Court at 2:37, and he lowered for it both home and distant signals on the wall road. Signals were put at "danger." He did not recollect looking at the electric indicator to see if the arms were responding to the levers, though he usually did. There was nothing that he felt in the movement of the lever to indicate that anything was wrong. After the collision the driver of the District train came up to the box and asked him if the driver of the other train had come out against his signals. Witness replied "No; it was you who came past the signal." To this the man rejoined, "My signal is off; look." Witness looked round and found that this was the case, but on looking at the electric indicator in the cabin he discovered that it showed the signal on. Mr. George Estall, resident engineer to the District Railway, deposed to visiting the scene of the collision shortly after the accident, when he found the down home signal on the Putney-road standing off, although the lever in the cabin was in its proper position of danger. An inspection revealed the fact that the vertical rod controlling the signal arm was broken. The rod was made of wrought iron, and was five-eighths of an inch in diameter. The metal was worn, but this was not visible. Charles Brown, telegraph foreman, said the electric indicators were last examined before the accident by a telegraph linesman, named Tombs, who would have reported to him if anything had been out of order. The inquiry was adjourned.

THE EARTHQUAKES.—It is reported from America that Cotopaxi in Ecuador began a serious eruption before daylight on July 23rd. Streams of lava, with ashes and stones, overwhelmed part of Chimbo, situated near Cotopaxi, and one hundred houses were destroyed. Guayaquil is 130 miles from Cotopaxi. The *Nacion*, of Guayaquil, reports that about 1 o'clock in the morning people were awakened by a heavy artillery apparently from guns of the heaviest calibre. The explosions followed one another with wonderful rapidity, sometimes causing a continuous roar, shaking the earth and causing the windows and the doors of the houses to rattle. A telegram from Chimbo to Guayaquil states that in that city, situated almost at the foot of the volcano, there was what the residents along the River Yana-Yacu call an aluvion. The phenomenon which these people understand by "aluvion" is really the stream of lava which descends the mountain sides, melting the snow with which it is covered, and pouring down a tremendous mass of lava, mud, stones, and all obstacles encountered in its progress. Investigation during the day showed that the shocks produced by the explosions during the night were exceedingly heavy. The smoke hung like a pall over the face of the country, and the steady fall of ashes thrown constantly out of the terrible crater intensified the darkness. Accounts from Latacunga state that the eruption began with a terrible storm. The damage done was considerable, but the number of victims is not known. A similar catastrophe occurred in June, 1877. According to a telegram from St. Petersburg to Scandinavian journals, dated August 4th, severe earthquakes have taken place at Tashkend and Wernoje in Russia. In Pishek every house suffered, and the new settlements Sukuluk and Belowodsk were destroyed. In the latter place the church fell in. It is stated that fifty-four persons were killed and sixty injured. The shocks continued to be felt several days, and there are great fissures in the earth.

THE WATERS RAILWAY SIGNAL.—The importance of electric signals in connection with railway service, says our American namesake, has directed the attention of many inventors to the subject. Their aim is to secure that absolute reliability which is apparently impossible under human oversight. A system invented by William T. Waters, of Atlanta, Georgia, comprises some novel and ingenious features. The operation of his block system is very interesting, and is designed to cover every necessary point in connection with the movements of railway trains upon either a single or double track system. It consists of a series of signalling stations which may be simply posts, with a metallic case containing the necessary mechanism to operate the semaphores. These stations divide the line into blocks, and each is provided with two distinct sets of signals. One set consists of semaphores for each direction, together with illuminated night signals for similar use; the second is a verifying signal, visible both day and night, operated from either direction, and recognised as a signal whenever seen. The first set consists of four semaphore arms or discs, mounted on rods pivoted within the signal box. Each pair of these discs form an advance and a rear signal. The night signals consist of lights in fixed positions, changed by transparent screens in connection with the day signals. The verifying signal is a revolving disc by day and a light by night, and the object of this portion of the system is to notify the engineer before leaving a given block, that his advance signal has or has not been diplayed at the farther end of the block he is then to enter. The verifying signal is the main signal of the system. The signal mechanism is operated by a reversible electric-motor provided at each post, which turns in either direction according to the circuit by which the transmitted impulse may arrive. The operation is entirely automatic, and is actuated by the movement of the train through the medium of a track circuit closer, or an insulated section of the rails as may be deemed most expedient. The signal posts are connected with an ordinary single wire by means of which the various movements are controlled. The signals are interdependent. One train can in no manner interfere with the signals of another; neither can a train, without adequate warning, approach nearer than the distance of one block to a post whose indications are already controlled by a previous train. These results are attained by a combination of electro-mechanical devices which have been arranged with a view to eliminating all possible elements of

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danger, and at the same time providing a system which can be introduced at a reasonable expense.

THE BRITISH ASSOCIATION MEETING.—The arrangements for the visit of the British Association to Aberdeen may now be said to be complete. Apart from hotels and lodging houses —whose owners cannot after all be blamed for trying to make science pay—the hospitality of the Aberdonians towards the members of the Association will be quite as lavish as that of any southern city, Most of the notabilities intending to be present, and all the officials who care for it, will be the guests of the leading people in the town and neighbourhood. There will be several garden parties in Aberdeen during the week, while the number of excursions already arranged for is alarmingly large. On the Saturday of the first week, by invitation of Her Majesty, 150 of the members will be taken to Balmoral by water and coach, and lunch will be provided for them. These will be shown over the grounds. Besides this it is said that arrangements are under consideration for the presentation of a few representative members of the association to Her Majesty. On the same day as the Balmoral excursion, parties of from 30 to 150 will be taken to Haddo House, Dunecht, Dunnottar, Drum and Crathes, Finzean, Glentana, and Loch Kinerd. On the Wednesday of the second week a party of 25 will be taken to Braemar, lunched, and driven about. And on the Thursday 200 will be taken to Invercauld, while other parties will be made up for Haddo House and Braes o'Gight, Huntly Castle, Elgin and Lossiemouth, Portsoy, Banff and Duff House, Edzell and the Burn. It is thus evident that ample preparations are being made for the entertainment of the learned visitors. So far as concerns the actual work of the meeting, the various sections will be well accommodated in the buildings of Marischal College and various halls in the neighbourhood. In Section A, Mathematical and Physical Science, it has been arranged to have discussions on kinetic theories of gases and on standards of white light. Prof. Crum Brown has consented to open the discussion on the kinetic theories, and has drawn up a short abstract of points to which he proposes to allude. In Section B, again, arrangements have been made for two discussions in the Chemical Section, over which Professor Armstrong will preside. The one will be on the determination of the Molecular Weights of Liquid and Solid Bodies, the other on Electrolysis. It is proposed to have a series of critical papers read which shall embody, as far as possible and desirable on such an occasion, our knowledge of these subjects, and also indicate the directions in which investigation is specially required and may be most usefully carried on. These subjects have been chosen as being of general interest and of special importance to the chemist, and in the hope of inducing chemists and physicians to co-operate in attacking the many problems which await solution. Captain Abney will open the first discussion with a paper on the Spectroscopic Method. Professors Guthrie, Reinold, and Dilden, Mr. S. U. Pickering, Dr. Russell, and Dr. Armstrong will also contribute papers. Professor Lodge will open the discussion on Electrolysis, and Professor Schuster, Captain Abney, and Mr. Shelford Bidwell have already consented to contribute papers on portions of this subject. Mr. Baker presides over the Mechanical Section (G).

THE ELECTRIC LIGHT IN A BLEACH WORKS.—The *Textile Manufacturer* contains an account on installation recently put down at the Bleach Works of Messrs. J. Whittaker and Company, of Radcliffe, near Manchester. The whole of the electrical arrangements have been carried out by the Manchester and District Edison Electric Light Company, under the direction of their manager, Mr. Williamson, in a most complete and efficient manner. The conductors are everywhere efficiently connected, instantly accessible, neatly laid and arranged with a view to the least possible liability to damage or risk. The lamps in each room are capable of being independently lighted or extinguished by means of a switch close to the door, so that the whole of the lights are instantly turned "on" or "out" with the greatest facility. The lamps are of the well-known Edison type, nominally rated at 16 candle-power each, but giving fully 20 candle-power. As some check upon this we may state that throughout the works 200 of these lamps replace about 350 gas jets, and we are assured by Mr. Whittaker that he has now more light than he ever obtained from the gas. Certainly the amount of light is ample in every case, and some of the rooms are brilliantly lighted. Some of these lamps have been in constant use in the Theatre Royal for over two and a half years, which gives a life of over 5,000 hours, but taking the safe average first given, the cost at the Mount Sion Works for renewal of lamps will not exceed £42 10s. per annum, which amount may be borne in mind when we come to deal with the comparative cost of the existing and superseded systems. The machine employed in the generation of current for the lamps is of the Elwell-Parker type, and is remarkably compact, as is shown by the following dimensions :—Length, over all, 5ft.; width, 2ft. 3in.; height, 2ft. 4in.; whilst its weight is slightly over one ton. The horse-power required to drive it varies, of course, with the number of lamps in use, but when working to its full extent about 24 to 25 actual horse-power is required. That it is working very much within its limit is shown by the fact that in no part of the machine is any heating effect appreciable, the commutator bars are wearing uniformly and smoothly, and no tendency is apparent for the formation of grooves. The bearings are long and lined with special metal, and the armature is so well balanced that, although running at 1,100 revolutions per minute, no vibration is appreciable. In ordinary circumstances power is obtained from a water wheel making from 26 to 27 revolutions per minute, but the gearing is so arranged that the machine may be driven by the works engine. The fact that the necessary power can be obtained from the water wheel during nearly the whole year of course makes the installation a favourable example in working cost, but there is another feature which in ordinary circumstances would render it a drawback. A water wheel necessarily revolves slowly, so that a slight variation of speed is tremendously magnified in the dynamo. In this cases the driving arrangements, however, are so well balanced and controlled that not the least degree of fluctuation in the light has been observed. In the matter of attendance it has been found that in a works of such dimensions the item may be totally disregarded, since it is no more than would be required for gas—that is to say, a few minutes daily for oiling and cleaning. No additional labour or attendance has been required. With reference to the comparative costs of the two systems, based on the average consumption of the last three years, the cost of gas burnt in the superseded burners was £330 per annum. We have already mentioned that the annual cost for lamps will be £42. 10s., the amount allowed for interest and depreciation is £32; adding to these items the cost for oil and waste and attendance, it will be seen that Messrs. Whittaker and Co. have some justification for their estimate that they obtain a better light with cooler rooms and purer air at about one-fourth the cost they were previously paying. It goes without saying that, being in the possession of practically free power, Messrs. Whittaker and Co. are favourably placed for making such a comparison; but those who have to pay coal bills may readily calculate what the extra cost would be, and they may also make allowance for the difference in the price of gas.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 272.)

Supposing now that we have, by the previous, satisfied ourselves that the distribution of current in the steady state is uniquely determinate by the subjection of the current to Ohm's law and continuity, and of the complementary force to being wholly polar, which last condition makes the activity of the impressed forces the greatest possible subject to conservation. The question then arises, how is this affected by the conductor being a dielectric as well, so that there must be elastic displacement in it? If we compare the dielectric conditions (87) with those for the conduction current (86), we see that they are of exactly similar form, except in the presence of ρ, the volume density of electrification. If, then, we start with $\rho = 0$, and proceed to find the displacement produced by the impressed force on the supposition that there is no conductivity anywhere (just as before, in the conduction problem, we assumed the specific capacity to be zero everywhere), we know that the displacement is uniquely determinate, as was the current before. Like the current, it is closed, and is so distributed as to make (not the heat) but the potential energy of displacement a maximum. The total work done by the impressed forces is twice this. The other half is not accounted for. In the transient state the energy is partly electric, partly magnetic; in the absolutely steady state it is wholly electric; practically there is always conductivity somewhere, so that half of the work is spent in the Joule heat of induced conduction currents, and is not radiated away, and, so to speak, lost. But that we have no concern with at present.

Now this distribution of displacement will not in general be consistent with that of electric current determined by the conductivity conditions. To be consistent, c the electric capacity, and k the electric conductivity, must be everywhere in the same ratio, or capacity × resistance (both specific) must be a constant. Hence, in general, either only one of the solutions is correct, or else neither. A little consideration will show that it is the conductivity solution that is correct, and that we must, after finding the distribution of electric force E from the conductivity conditions without any reference to those of capacity, determine the displacement and electrification to correspond to the thus found electric force by the first two conditions of (87), viz.,

$$D = cE/4\pi, \qquad \rho = \text{div. } D.$$

For we thus satisfy all the conditions, which we could not do by starting with the dielectric problem, finding E to suit, and from it, finally, the distribution of current. Why we are able to solve the problem by the conductivity conditions alone is mathematically accounted for by the presence of ρ in the continuity condition relating to the displacement. The distribution of displacement (or polarisation) D, and the distribution of electrification ρ are such as to have no polar force when existing together; or the polar force of the displacement alone and that of the electrification alone are equal and opposite. Thus the electric field is not in any way disturbed, and the current is therefore also undisturbed and independent of the existence of elastic displacement.

On this point it should be remembered that whereas in considering a magnet as a collection of very small magnets, or any very small portion of the magnet as being polarised, the positive end of a polarised particle is that end to which the vector polarisation points, and is the end upon which positive magnetic matter may be assumed to be collected; yet, on the other hand, if we do the same with electric polarisation, it is the negative electrification that is on the positive side of a particle, that to which the vector displacement points. We cannot, in the magnetic problem, imitate the above state of electric displacement and electrification having no polar force. For the magnetic analogue of D, which is $B/4\pi$, B being the magnetic induction, is always continuous.

Now, to go further. At the commencement we assumed that the conductivity nowhere quite vanished, so that we have been so far considering the current and displacement produced by given impressed force in an infinite conductor, in which k is finite everywhere, whilst c is quite arbitrary, and may vanish in certain portions if we please; it being the conductivity conditions alone that determine the field of force. But, practically, we must regard certain parts of space as being wholly non-conducting. This, though apparently included in the preceding, viz., by taking the special value $k = 0$ in certain spaces, really, to a great extent, necessitates a changed mode of treatment. It is not sufficient to find E from the conductivity conditions, putting $k = 0$ in non-conducting space. For this will not give the proper field in the non-conductors, but only in the conductors, unless at the same time $c = 0$ in the former, or, in special cases, c = constant.

Also, it may happen that when the conductivity is finite, though very small, in certain parts of space, it will be practically necessary to suppose it to be quite zero, on account of there being a first approximately steady state, and then, a long time after, a wholly different, quite steady state; which last, though it is not what is practically wanted, is what the conductivity conditions give. Consider, for example, a submarine cable whose ends are earthed through condensers. Put a battery in circuit at one end. The practical steady state is reached quickly, in a few seconds (of course not counting disturbances or absorption). But as the dielectric is slightly conducting, if we keep on the battery, the "charge of the cable" will in time —minutes or hours, according to the insulation—nearly disappear; theoretically, in an infinite time. This is the real final state, but the first approximately steady state is what is practically wanted, given, very closely, by assuming $k = 0$ exactly in the dielectric.

Now divide all space into two sets of regions, the conducting and the wholly non-conducting, including in the latter the dielectric in such a case as just mentioned. All conducting matter which is continuonsly connected must be regarded as a single conductor. Thus all the wires on a line of poles, if they are earthed, together with the earth, and all that is in conducting connection with it, forms strictly a single conductor. But if we loop two of the wires, removing earth, they form a separate conductor. (Leakage ignored.) There may thus be any number of distinct conductors, each self-continuous, but wholly separated from all the rest by non-conducting matter, or else unbounded partly, though the last is, as regards conductivity, practically unrealisable. Similarly the rest of space, the nonconducting space, forms a number of self-continuous regions, each either wholly bounded by conducting matter, or else partly unbounded, which last is practically realised.

Now, selecting any one of the conducting regions, let the impressed force e be given in it. It is readily shown, by the simplest modification of the conduction problem for all space, that C (and of course E) are definitely fixed by the distribution and e and of conductivity. The modification consists in applying the space integrals to the finite space occupied by the conductor, at the same time introducing the surface condition that the current is confined to the conductor or is tangential at its boundary, which condition is expressed by $CN = 0$, if C be the surface current density and N the unit vector normal to the surface. But this modification may be wholly avoided by integrating through all space as before, thus including surface terms, on the assumption $k = 0$ outside the conductor. The solution obtained applies to the conductor only, that part for the external space must be wholly rejected. There is an exception, namely, if $c = 0$ as well as $k = 0$ in the whole external space, when the external solution for the electric force will be the correct one, as will also be the case sometimes if c = constant.

Thus the internal electric state of any conductor depends solely on the conductivity and the impressed force in it, and is independent of all external conditions. (This is not true for the magnetic state of the conductor, which will be influenced by the external conditions not only as regards permeability, but as regards currents and magnetisation, but at present it is only the electric state that is in question.) We therefore settle the electric state of the whole of the conducting part of space, one conductor at a time. Not only that, but in the same manner as before done in the case of the infinite con-

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ductor, we settle the displacement and electrification in every conductor, one at a time, from the known electric force in them, making no alteration whatever in the electric field.

There remain, finally, the non-conducting regions, and now the matter gets rather more complex. So far our knowledge ceases at the boundaries between the conducting and the non-conducting regions. But at every point on these boundaries, on the non-conducting side, the tangential component of the electric force is fixed. For the second equation of induction is

$$\text{curl}(e-\text{E}) = 4\pi\text{G} = \mu\dot{\text{H}}, \qquad (23)\ bis$$

where G is the magnetic current, H the magnetic force, μ the permeability. Here $\text{E}-e=\text{F}_1$ the electric force of the field by itself, not counting impressed force. Applying the Version Theorem to this, interpreting it for a mere surface, we see that the tangential component of F_1 must be the same on both sides of the surface. Otherwise the surface would be the location of a magnetic current sheet, of strength G per unit area. This continuity of the tangential component of the electric (similarly of the magnetic) force of the field is true whether the state be steady or not. When not steady F_1 is not polar. At present $\text{F}_1=\text{F}$ and is polar. We know then the tangential component of F (including its direction) at every part of all the boundaries. In terms of potential, we know its surface variation over every boundary, but not its absolute magnitude. The last is unknown, not merely as regards a constant, but as regards n constants, one for every conductor, which, if we choose to employ potentials, must be mutually reconciled, so as to leave only one of them arbitrary. Now we cannot do this without knowing the state of the dielectric non-conductors. The potential must be found last of all, even in the conductors, whose electric state is independent of one another. Obviously, even were there no other reason to give, this would be a powerful argument against potential representing any physical state, in the same manner as electric force, current, &c., do.

As before we took the conductors one at a time to completely find their electric state independently, so now we may take the non-conducting regions one at a time, and find the electric state of each independently of the others. Selecting, then, a single non-conducting region, the conditions to be satisfied within it are

$$\text{D}=c\text{E}/4\pi, \qquad \text{div.D}=\rho, \qquad \text{curl}(e-\text{E})=0, \quad . \quad (87)\ bis,$$

where now, of course, e is the impressed force at the point considered. Or, eliminating D, and putting $\text{E}=e+\text{F}$, F being the polar force,

$$\text{div.}c(e+\text{F})=\rho, \qquad \text{curl F}=0. \quad . \quad . \quad . \quad (90)$$

The electrification density ρ is now not to be *found*, as in the conductors previously, but must be *given*. Thus e, ρ, and c are given at each point, and D, E, F have to be found, or simply F, since that fixes the others.

There is also the before-stated boundary condition; FN being the normal component of F, (FN)N is the vector normal component, so that it is

$$\text{F}-(\text{FN})\text{N}=\text{V}\{(\text{VFN})\text{N}\} \quad . \quad . \quad . \quad (91)$$

that is given over the bounding surface or surfaces. Or, simply VFN, the tangential F turned through a right angle on the surface, may be regarded as given.

A preliminary examination, as regards energy, of the three conditions (90) and (91) shows that they are insufficient to determine F. We need to know, also, the boundary representatives of ρ the electrification. But it is not the electrification at every point of the boundaries, but only their totals, that is needed, *i.e.* the charges. Let q_1, q_2, &c., be the charges of the separate surfaces, then

$$q_1=\Sigma\text{DN}_1,\ q_2=\Sigma\text{DN}_2,\ \&\text{c.} \quad . \quad . \quad . \quad (92)$$

must be given, D being the displacement at a surface, and N_1, N_2, &c., unit normals from the conductors to the non-conductor.

For it is clear, by the continuity of the electric current, that if a conducting surface, wholly surrounded by dielectric, had a charge before the impressed force in the conductor began to act, such charge will not be altered in amount, though its distribution may be changed when the impressed force acts. Similarly, impressed force in the dielectric cannot alter its amount, but only its distribution, nor can the introduction of external electrification. The same applies partly when the conducting surface wholly surrounds a dielectric, neither e in the conductor nor the dielectric can charge it. But, on the other hand, the introduction of any interior electrification, by continuity of the current, requires the surface to have a total charge equal to the whole interior electrification taken negatively. In any case, then, Q_1, Q_2, &c., must be known, independently of external electrification, in the one case, or depending on interior electrification in the other.

We make no distinction between simply and multiply connected regions, *e.g.*, a rod and a ring, because there is no difference whatever required in the mathematical treatment, if we keep clear of the potential. But it will be convenient to break up the problem into two, thus:—

(*a*) Given e, ρ, and Q_1, Q_2, &c., and that VFN = 0. Find F.

(*b*) Given VFN, and that $e=0$, $\rho=0$, $q_1=0$, &c. Find F.

We take (*b*) first, as it is the simpler, and is also directly connected with the conduction current. That is to say, we suppose that before the impressed forces in the conductors began, the whole system was free from electrification or impressed force in the non-conductors. We have

$$\text{div.}c\text{F}=0, \quad \text{curl F}=0, \quad \Sigma\text{DN}=0, \quad \text{VFN}=4\pi g, \qquad (93)$$

F being the force in the region. The first two apply to every point in the region, the third to any conducting bounding surfaces as a whole, whilst in the last g is given over the whole boundary. We have

$$\Sigma\text{F}_1c\text{F}_1=\Sigma\text{F}c\text{F}+\Sigma fcf+2\Sigma\text{F}cf \quad . \quad . \quad . \quad (94)$$

if $\text{F}_1=\text{F}+f$, whatever they be. Suppose now F to be a solution of (93), and f to satisfy the second and fourth conditions, so that F_1 is a solution of the second and fourth, but is otherwise unrestricted. By the first D is continuous within the region, and, by the third, at its boundaries as much leaves as enters the region. We may therefore close D completely outside the region without disturbing D within it. D, thus extended, is a wholly closed flux, and therefore may be represented by $4\pi\text{D}=\text{curl}\text{Z}$, where Z is determinate in various ways. This makes

$$\Sigma\text{F}cf=\Sigma f\text{curlZ}/4\pi=\Sigma\text{conv.V}f\text{Z}/4\pi. \quad . \quad . \quad (95)$$

This summation extends through the region. By the Convergence Theorem, the last form is at once expressible as a surface integral over the boundary, viz.,

$$\Sigma\text{NV}f\text{Z}/4\pi=\Sigma\text{ZVN}f/4\pi=0$$

the vanishing taking place because $\text{V}f\text{N}=0$. Thus $\Sigma\text{F}cf=0$. Therefore, by inspection of (94), $\Sigma\text{F}_1c\text{F}_1$ is made a minimum by $f=0$, making $\text{F}_1=\text{F}$, and proving F to exist. That it is unique follows by the same reasoning as in the conductivity problem.

The physical interpretation of the above, as regards Z, which is best taken as the magnetic impulse, or time integral of the transient inductive magnetic force, is interesting, but must be left over. In the above, however, Z may be any vector whose curl is D in the non-conductor, its curl in the conductors being arbitrary. Thus, if we close D in any manner through the conductors, and call the complete system D_1, then

$$\text{Z}=\text{curl}\Sigma\text{D}_1/4\pi r+\text{any polar vector}$$

satisfies the requirement. Or, instead of the curl of the vector-potential of D_1, we may form the vector-potential of its curl.

As regards the transformation used in (95), if f and Z are *any* vectors, we have

$$\text{conv.V}f\text{Z}=f\text{curlZ}-\text{Zcurl}f;$$

and (95) follows because f has no curl.

Lastly, the assumption made in the above demonstration that F_1 is possible, to satisfy the second and fourth of (93), though nearly obvious, is made evident by constructing any scalar potential whose tangential variation at the boundaries is of the required amount, its value elsewhere being arbitrary, and letting F_1 be its slope.

(To be continued.)

ROYAL ENGINEERS AND THE POSTAL TELEGRAPHS.—Capt. Beresford, R.E., having returned from Egypt, resumes the command of the Royal Engineers and his position as Superintending Engineer of the Southern District.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE PURCHASE OF SUBMARINE CABLES BY GOVERNMENT.

In the article from *The Times* which we reproduced in our last issue, the writer, after discussing the question of uniform tariffs, comes to the remarkable conclusion that "the Government would inevitably be landed, sooner or later, in the acquisition of the undertakings of all the cable companies, so far as regards European communications, and the taxpayer would in all probability pay a great deal more than the property of the Companies was worth, as he did on the purchase of the inland telegraphs, and perhaps be called upon to work a losing undertaking into the bargain." No doubt this is the conclusion to which we have all come after a more or less casual consideration of the subject. The matter, however, on a further examination, is not so simple, and ultimately the opposite conclusion is reached, viz., that it is impossible for any Government to purchase or own the system of cable connections even of Europe much less of the whole world. What are the facts of the case? How has the cable system been built up? At the end of the forties and beginning of the fifties English capitalists determined to connect the Continent electrically with England. They succeeded. Success put promoters and capitalists upon this new track, and gradually—and principally with English capital, energy, and pluck—the present network of cables has been laid. The cost of cable work is enormous, and in almost every case the promoters, in order to protect themselves, obtained concessions to guard against undue competition. The political signification and value of the work were altogether unrecognised, and hence the concessions were obtained with comparative ease. The commercial benefit was the sole object recognised. As years passed by the value of cable communication to the various Governments was more and more appreciated, till at this day it is admitted to be a political necessity. The value of the cable system commercially is at its highest when the system reaches every part of the civilised globe. A perfect political system to any one nation would be one entirely in the hands of that nation. Now, is it to be expected that any one of the great Powers, or, for the matter of that, any one of the minor Powers, would agree, singly or in combination, to a scheme putting such enormous controlling power into the hands of the holder of the system? To put the matter bluntly, Is England prepared to see Germany, or France, or Russia, purchase the whole of the cable system of Europe or of the globe? The answer to such a question is soon given, and is emphatically "No." Is it likely, then, that France, or Germany, or Russia, would permit the Government of England to become the owners of the cable system? The answer is similar, and is just as emphatic.

Under existing conditions each Government granting concessions is able to make its own terms with the Companies, and to compel those terms to be strictly carried out. Perhaps some one will be inclined to argue that international terms could be similarly arranged. So they could if mankind were angels, and the aim and objects of each Government were exactly similar. But it is well known that political clouds do arise between each and every Government, and it is not to be expected but that at such times the Government owning the cable system would be at a great advantage as regards all other Governments. The more the whole question is discussed the less probable is the idea of Government control. The loss of a million pounds to the English Government would be insignificant if a political object were to be gained; but no company could act in such a manner as to lose that sum, as well as in all the future to suffer from the after effects of the act. The various Governments can effectually control the action of the Companies, while such control would be obviously weak with the cables in the hands of a powerful nation.

The primary object of a cable company is to earn a dividend. Hence the development of the cable system in the hands of companies is of a commercial character, while in the hands of a Government it is difficult to see how such a character would be maintained. The moving idea with the Government would naturally be political. The cable system would be subservient to political exigencies, which it is now only to a minor extent. That any Government should protect itself is quite natural; but at present they can connect special points with the system by giving a subsidy, thus obtaining their object at a much less cost and with far less risk than by laying and maintaining the cables themselves. We commend these and similar considerations to the minds of those who may be able to influence the question one way or the other, and we shall be surprised if, after maturer thought, these conclusions are not accepted. We may imagine what would happen if at this moment no cables existed while we had the knowledge, scientific and practical, of the possibilities of such cables; and no doubt upon paper we could build up a magnificent system—supposing no opposition from any foreign country would be raised. But to any such scheme we know perfectly well that a most strenuous and effectual opposition

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THE INTERNATIONAL INVENTIONS EXHIBITION.

Forbes' Non-Polar Dynamo.

Those visitors at the Inventories who are interested in technical matters will probably have noticed a peculiar model of a dynamo, with some explanatory diagrams, at the stand next to that of Mr. Swan. By-the-bye, a passing word may be said in praise of the artistic and excellent display by Mr. Swan. There is no doubt that this stand is by far the most attractive of those in the annexe. The lamps are arranged in various groups, and vary from the diminutive lamp—a number of which are used to scintillate in an ordinary sized brooch—to the largest and most brilliant of those used in practical lighting. An interesting object, too, is a handkerchief spun with the new material used for the filaments, showing that the celluloid material has a wider use than at first sight might seem probable. The attendants at this stand are to be complimented upon the taste displayed in producing such an attractive show.

We must, however, return to the discussion of the real object of this article, viz., Prof. G. Forbes's dynamo. Externally this machines gives few or no indications of its construction. The model looks like a simple hollow cylinder of iron, with a slot cut, through which a couple of wires are carried, rotating around its axis. The machine at work will be found close to Galloway's engine, and looks like an iron cheese with wires sticking out at the top. We give in Fig. 1 a perspective view of the machine to show its external appearance, while we are indebted for the following description of it to the *Engineer*:—At the west end of the North Court is exhibited a most remarkable machine intended for the electro-deposition of copper by means of a very large current flowing through a bath of copper sulphate. A smaller machine of a similar character is exhibited in the East Arcade, as also a number of drawings showing full size sections of Professor Forbes' machines. Before we can enter into a detailed description of these we must say a few words about the general principle of these unipolar, or, as Professor Forbes prefers to call them, non-polar machines. The latter term seems the more appropriate of the two, as no external magnetism can be detected when the machine is at work. No such thing as one isolated magnet pole can be found in nature; there must always be two poles of opposite sign, although only one of them may be directly utilised. In Professor Forbes' machine, however, both poles are utilised, and as both are well within the body of the machine, which consists almost entirely of wrought iron, none of their magnetic force is wasted externally, as is the case more or less with all other dynamos. The subject of unipolar dynamos is not new, about thirty patents having been taken out within the last few years; but the difficuties of rubbing contacts at high speeds have always stood in the way of their practical application. Not the least of the merits of the machine under consideration lies in the successful manner in which this difficulty has to all appearances been overcome. In the beginning of these articles it was pointed out that the electromotive force in all dynamo electric machines is due to the cutting of lines of magnetic force by a conductor, the direction in which the electromotive force is set up being at right angles to the direction of movement and also at right angles to the lines of force. If a metal disc be fixed, as per sketch (Fig. 2), between the poles of a horse-shoe magnet, and rotated in the direction of the arrow, an electromotive force would be created in direction downwards from the axis to the circumference, and by arranging rubbing contacts on the axis and at the lowest point of the disc a current could be taken off. Other things being equal, the current will be strongest if the poles are arranged to come very close to the disc, and in some cases it might be advantageous to make the disc of soft iron in order to reduce the resistance of the magnetic circuit, and to further intensify the magnetic action between the two poles. The arrangement shown in our sketch produces a current only along one vertical radius of the disc; but if we were to place a number of magnets all round the disc, and arrange a corresponding number of rubbing contacts, equal currents could be taken off along these radii; and if the magnet were made in the form of a ring-shaped shell, currents could be taken off along the whole circumference. This is in substance what Professor Forbes has done. In his machine the shell is an electro-magnet excited by a circular coil placed in the bend of the yoke, and the disc is made of iron of considerable thickness, partly to obtain a large surface of contact, and partly to reduce its internal resistance. In the first machine constructed on this principle the disc was made so wide that it became a cylindrical bar. Two coils were placed over it, leaving a space of about 1in. in the middle for the contact. The shell is in the form of a cylinder about 13in. long and 5in. in diameter. The bearings of the bar—which is the armature—formed one pole, whilst the other pole was the rubbing contact in the middle. This machine will be found on Stand 1,324 in the East Arcade. The next step taken by the inventor was to construct a double machine according to his patent No. 3,115, 1883. We give a longitudinal section of this dynamo in the sketch (Fig. 3), omitting, however, all constructive details. Two discs, D D, are mounted

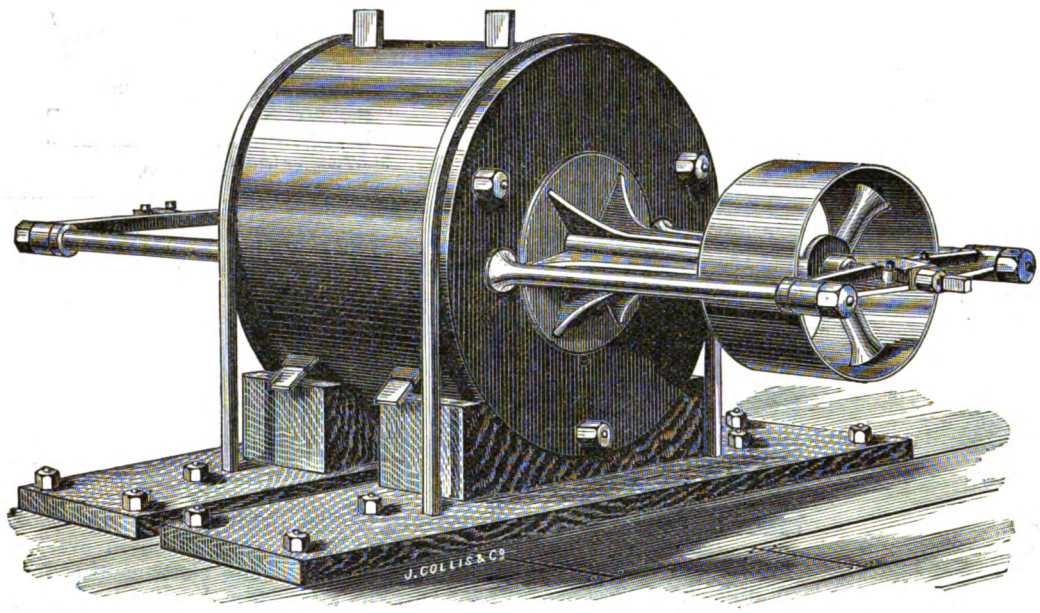

Fig. 1.—Forbes' Non-Polar Dynamo. Perspective View.

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upon the same spindle, and revolve within a duplicate cylindrical shell of soft iron, S. Rings of trapezoidal cross section are turned out of the shell, into which are placed the insulated exciting coils *c c*. The lines of force created by the current in these coils surround them in closed curves as indicated by the dotted lines, and since the direction of the current is opposite in the two coils, the lines cut the first disc in opposite sense to the second, setting up in one disc an electromotive force inwards and in the other disc outwards. The current flows from the outer circumference of the first disc towards its centre, then along the axis to the centre of the second disc, and thence outwards to its circumference. The rubbing contact is at the periphery of each disc, and at first it was attempted to use mercury for this purpose, the mercury being retained between india rubber rings, as shown. It was expected that under the influence of centrifugal force the mercury would form a band of about equal thickness all round the circumference, and thus establish the best possible contact. Experiment proved, however, that mercury behaved more like a solid belt than a liquid band, adhering for a considerable distance closely to the disc but not touching the casing, and in other places leaving the disc and flying out to the casing. It was also found that the liquid friction of mercury was by far greater than is commonly assumed, and in consequence of this considerable heating took place. These difficulties fairly recognised, Professor Forbes cast about for a remedy, and discovered that iron and carbon form a splendid contact, which will work at high speed without heating and without appreciable wear. Engineers

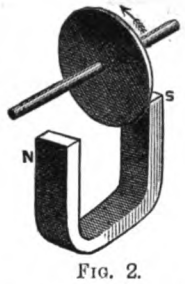


FIG. 2.

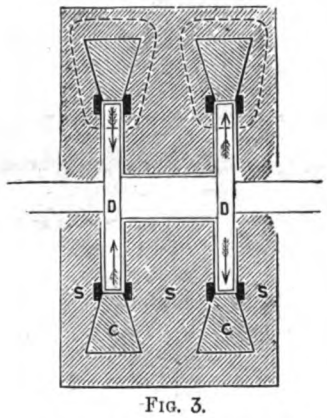
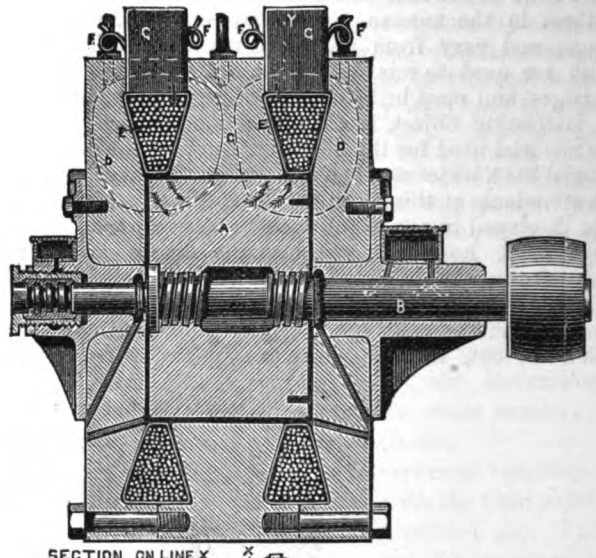


FIG. 3.

will, perhaps, be less surprised at this than electricians, for they have long known that, with polished shafts, bearings consisting mostly of carbon in one form or other can be made to wear for years without any lubrication whatever. Professor Forbes has therefore adopted carbon contacts, not only in all of his machines, but he also proposes to use them in all cases where rubbing metal contacts have hitherto been employed, especially for the brushes of dynamo machines. If he succeeds in this he will deserve the thanks of all makers and users of dynamos. At present the commutator is that part of a machine which wears most, and in many cases it is costly to replace; but if by the employment of carbon brushes the wear of the commutator can be reduced to a fraction of its present amount, the cost of keeping dynamos in running order will be reduced almost in the same proportion.

The diagrams exhibited on Stand 1,324 give, so to speak, the whole history of the invention. They show how the original idea was developed, assuming more and more a practical shape. Thus we find the next improvement represented in a drawing which we reproduce in Figs. 4 and 5. The machine shown in the above sketch has evidently more internal resistance than absolutely necessary; for by making the discs wider we could increase their conductivity without in any way lessening the number of lines of force which pass through them. It is not even necessary that the machine be any heavier, as we can widen the discs at the expense of the central mass of iron between them. Imagine, now, that we gradually widen the two discs by allowing their inner faces to approach more and more until they meet and form one continuous cylinder. We shall thus obtain not only a maximum of conductivity, but also the additional advantage of having transferred the two inner air spaces to the circumference of the cylinder, where, on account of the larger surface, their magnetic resistance is somewhat diminished. This arrangement is represented in Figs. 4 and 5. The dotted curves show again the

FIG. 4.



SECTION ON LINE X

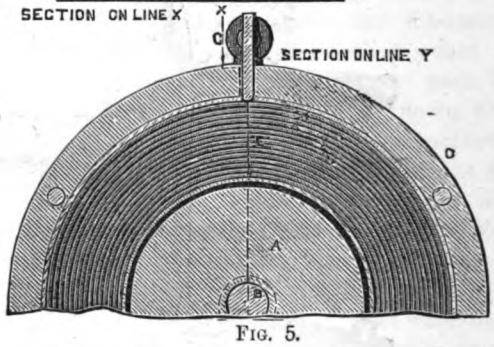


FIG. 5.

character of the lines of force, and the arrows indicate the direction of the currents, which in every point are vertical to the lines of force. The electromotive force is proportional to the speed of rotation, and to the total number of lines passing through the armature. If we assume the same degree of saturation for different size armatures, we find that the electro-

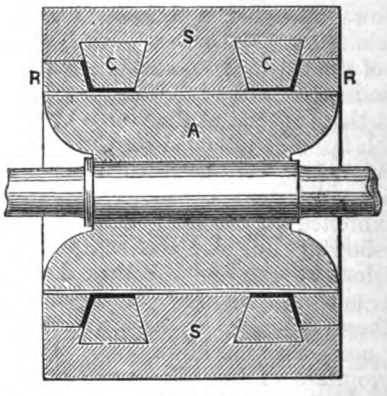


FIG. 6.

motive force is proportional to the square of their diameter. The machine just described, although being a great improvement upon the former type, has the defect of being liable to an enormous side-thrust consequent upon inequality of magnetic attraction on the two end faces of the armature. It is practically impossible to so place the armature that the clearance on either side should be mathematically equal, and hence a certain amount of side pressure must always

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exist, which necessitates the employment of a thrust bearing as shown. To remedy this defect Prof. Forbes has designed a modified arrangement of the cylinder machine, which will be understood from Fig. 6. We again omit all constructive details. The armature A is 6in. diameter and 9in. long; the ends are turned out to the shape shown, so as to afford an equal area for the passage of lines of force at all points. What in an ordinary dynamo would be called the field magnet, is represented here by the shell S containing the two exciting coils C C. The cross section of these is trapezoidal as before, in order to leave as near as may be an equal area of soft iron round these coils for the passage of the lines of force. Part of the shell consists of two soft iron rings R R, which are insulated from the body of the shell and form the terminals of the machine. Two copper rings of angular section, shown in our diagram by thick lines, form the rubbing contacts. They are provided on the inner circumference with teeth, by means of which the ring of carbon, which is continuous all round and which forms the contact proper, is held in place. The air space or clearance between armature and shell is $\frac{1}{16}$in. This machine has not yet been finished, but from experiments made with other machines it is expected that it will give a current of 5,000 amperes at a difference of potential between terminals of two volts if driven at 2,000 revolutions per minute. For lighting purposes a similar machine could be made with a larger armature. If the cylinder be 4ft. in diameter and 4ft. long, it would give 60 volts at a speed of 1,000 revolutions. Such a machine would, however, be too cumbersome in comparison to the output that could possibly be required of it, although not too cumbersome as compared with the output it could give. It is also doubtful whether, at a speed of 12,500ft. a minute, even carbon contacts will stand. The inventor proposes, therefore, to obtain higher electromotive forces not by increasing the size of his machines to unwieldy proportions, but by making compound armatures, as shown in Fig. 7. The different cylinders are to be insulated from each other, and each is to be provided at the ends with rubbing contacts also insulated from each other. The contact 2 would be connected to 3, 4 to 5, and so on, the current entering the armature at 1 and finally leaving it at 10.

Another form of the non-polar dynamos is shown in Fig. 8. Only one exciting coil, C, is employed, consisting of a spiral of insulated flat sheet copper laid into a circular trough of cast iron, which is fastened to the armature and revolves with it. The sides of this trough carry the carbon contact plates, and contact is insured with the rings R R,

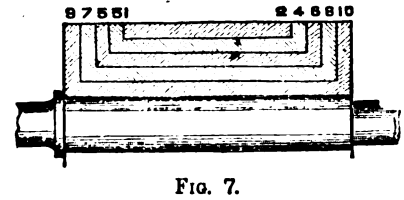

Fig. 7.

which form one terminal of the machine, by the magnetic attraction between the trough and these rings. The rings are insulated from the body of the machine, and have a little end play, so that they can be attracted towards the carbon discs. Suitable stops prevent them from turning. The other contact is formed by two carbon discs fastened to the ends of the armature, and the body of the machine forms the other terminal. The lines of force surround the exciting coil, as shown by the dotted curve, and the currents which cut these lines at right angles flow from the cast-iron trough outwards to the ends of the armature, as indicated by the arrows. The armature of this machine is 9in. in diameter and 8in. long, and is calculated to give a current of 10,000 amperes, at an electromotive force of one volt, if driven at 1,000 revolutions per minute.

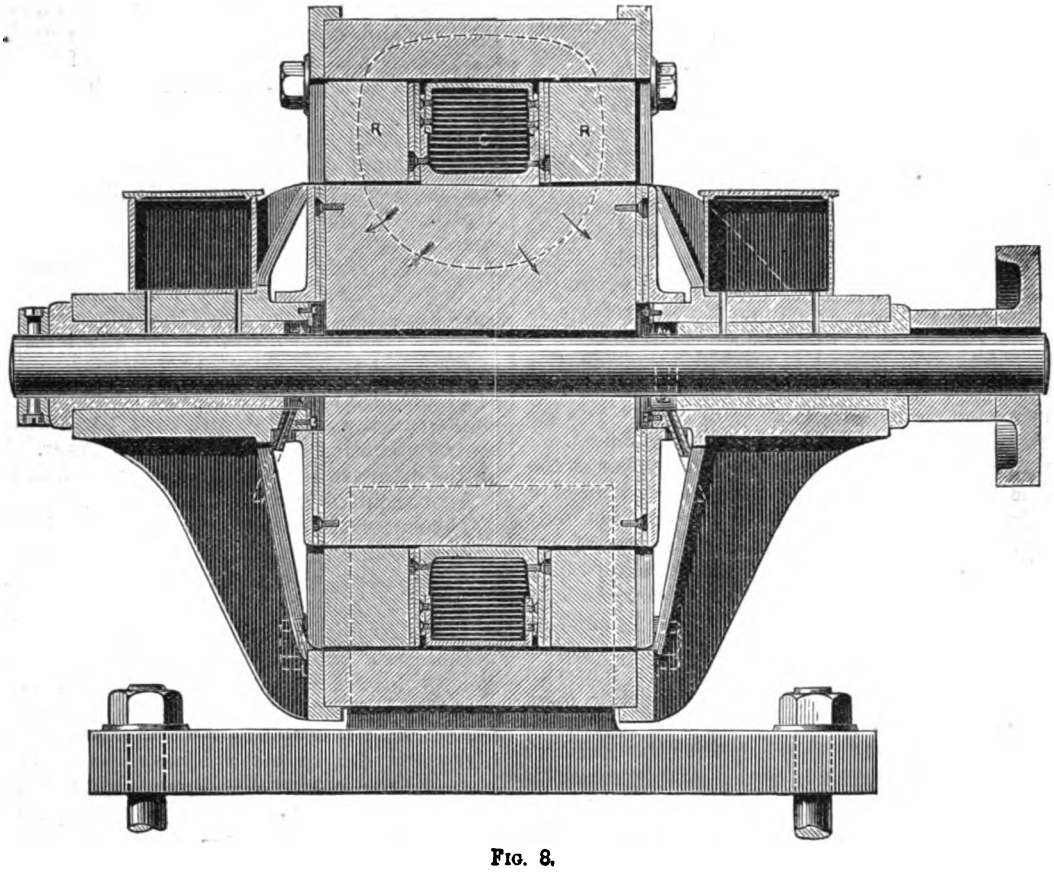

Fig. 8.

The machine shown in action is used to deposit copper, and is not intended for electric light work. We have always maintained that too little attention is usually paid to the construction of machines for special purposes; but there is gradually growing into vogue a better state of things, and few people now imagine that a dynamo will indifferently generate a current for arc or incandescent lighting or for electro-deposition. The field for the utilisation of electricity for lighting operations is extensive, the borders are scarcely explored; but this field is, we believe, small compared

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with that of the use of electricity in electro-metallurgical and electro-chemical work. These latter are veritably fields of promise to the young investigator, and will amply repay all his attention to them. Whether Prof. Forbes has designed a machine that will prove the best for electro-deposition remains to be seen; but we understand that the experiments carried out under the auspices of the Franklin Institute last year in America showed that it gave results superior to those obtained from any other machine before the jurors.

THE FOUNTAINS.

In the second edition of the catalogue, which has been thoroughly revised and extended, is a description by Sir Francis Bolton of his arrangements to illuminate the fountains. It is not too much to say that the beautiful effects obtained by the illumination of the gardens, and especially of the fountains, have proved most attractive to the public, and have gone far to make these South Kensington Exhibitions so successful. We have seen illuminations in many Continental cities, but nothing to compare with the nightly exposition as developed under the genius of Sir Francis Bolton.

In the ornamental water, in the grounds, fountains of various designs have been arranged (invented and designed by Colonel Sir Francis Bolton, C.E.), which are illuminated after dark by means of powerful electric arc lamps. The following is a description of the means by which the effects shown by the fountains are produced:—The water for supplying the fountains is delivered direct from the West Middlesex Water Company's Hammersmith pumping station. The main enters the Exhibition grounds from the north-west, and is conducted to the four water meters, on the western side of the centre basin, which register the quantity of water consumed. From this point a large main leads to the central "island," where the principal jets rise. The water is supplied at a pressure of about 70lb. to the square inch, which is sufficient to carry it to a height of 120ft. The island is reached by means of a subway, and through this are laid the cables for the electric current and the signalling wires. The whole of the jets are worked by screw-valves and levers placed inside the island.

The fountain display is directed from the clock tower at the south side of the garden, the "operating room" being below the dial of the large clock. The operator controls not only the working of the jets, but also the colour and power of the lights, by a series of electric signals, arranged on a key-board with 48 keys, in three rows of 16 each, which communicate with bells and indicators inside the island. The illumination of the water-spray, which produces brilliant effects when falling, is effected from the seven small islands, and a powerful projected light from the clock tower. The machine room inside the island is an apartment 21ft. square. Its roof being only 5ft. from the floor, renders it impossible for the operators to stand upright in it. The floor is crossed and recrossed in all directions by iron pipes, conveying the water from the main to the various jets.

The fountains are set in action by screw-valves fixed vertically on the different branches attached to the water mains. The large jets, which send the water to the greatest heights, are worked by plug-valves and levers, so as to allow an instantaneous start and stop, which causes a shower of spray. There are altogether eleven wheels and three levers. The wheels are nearly equidistant round the room, the levers being in the centre. In some cases the valves are opened and closed by hydraulic rams controlled by an electric current from the operating room. In the roof are five circular skylights of very strong glass, one of them being exactly in the centre, the others forming a square about it. Under each of these sky lights is a wooden stand, on which is fixed a hand arc lamp of 8,000 candle-power. Over each arc is a lens, which concentrates the light on the jet. When the order "Lights on" is received, the five arcs are set going, the result being to powerfully illumine the jets of water internally, while the dropping water or spray is illuminated externally by the surrounding beams of light, thus producing a glistening effect. There is also a lamp opposite the cascade, the light being concentrated by a plano-convex lens. The current for these lamps and for the lamps in the seven small islands is supplied by a B 12 Siemens machine. These machines are placed in the electric light shed. The usual staff is seven—one man to work the valves, five to attend to the lights, and one to watch and reply to the bells. They cannot see what is going on outside, their only means of knowing that all is right being the signals from the clock tower. The quantity of water sent up averages 70,000 gallons an hour; but when all the jets are going at once 1,000 gallons are used in fifteen seconds. The lamp over the clock tower is placed in a projector kindly lent by the Chatham Military School of Engineering, the current for it being obtained from a Bürgin-Crompton dynamo.

THE GARDEN ILLUMINATIONS.

The grounds of the Exhibition are lit up by about 9,700 electric glow lamps of 5 and 10 candle-power, with a few 20-candle lamps on the band stands and on the verandah of the conservatory, the design of Colonel Sir Francis Bolton, C.E.

These lights, many of which are brilliantly coloured, have been placed partly on the permanent museum buildings and on the conservatory, so as to bring out the tracery of these buildings, and to give an appearance of vastness to the grounds, and partly on the balustrades, round the flower beds, and in the trees and ornamental water of the gardens, the general effect being a charming arrrangement of light and colour. The lights can be turned on or off either by sections or altogether instantaneously. Messrs. Siemens Brothers are the contractors for the installation and maintenance of the whole of these garden illuminations. The installation consists of 23 circuits, each of which is made up of eight parallels of lamps connected in series, the electromotive force of the 5 and 10 candle-power lamps being 25 volts, and that of the current at the machines 220 volts. Each of these circuits is connected to the main leads from the dynamos by an interruptor controlled by a solenoid, placed in the switch-house near the engines. There are also four interruptors on the main leads, similarly controlled, and by means of which resistances can be inserted, so as to diminish the power of the lamps. These solenoids are worked from a switch-board with 10 switches placed in the central operating room in the clock tower. The interruptors on the main are also worked from the clock tower. The total current required is about 750 amperes.

The current is obtained from three of Messrs. Siemens' B 13 self-regulating dynamos, each of which can supply a current of 450 amperes with an electromotive force of 250 volts when running at 300 revolutions.

The four series coils, which are coupled in parallel, are wound with copper wire 0·4in. in diameter, and the shunt coils, which are coupled in series, with No. 9 Sd. W. G. The armature is wound with flat strips instead of wire. Each of the dynamos is coupled direct to a Goodfellow and Matthews high-speed compound triplex engine, fixed on the same bed-plate. Each engine has three high and three low-pressure cylinders, placed tandem, and at an angle of 120 deg. The principal dimensions are:—

Height above bed-plate	6 ft. 6 in.
Length over all	7 „ 6 „
Width	7 „ 7 „
Diameter of high-pressure cylinder	9 „
Diameter of low-pressure cylinder	18 „
Length of stroke	10½ „
Approximate weight	5 tons.

They each indicate 180 horse-power when running at 300 revolutions, with steam at 120lbs. pressure. The steam is supplied by three of Babcock and Wilcox's water tube boilers, which are placed just outside the Quadrant, and between it and the Albert Hall.

As will be seen from the power of the dynamos, two of them would supply considerably more current than is required for the 9,700 lamps. One machine will therefore be spare; but will be kept running ready to be switched in should it be required. As a further security against accident, means have been provided by which the number of lamps can be reduced to what one machine can safely supply without materially affecting the illumination of the grounds.

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would be raised; and similarily any attempt to adapt the actually existing system to the political needs of any one or two Governments would rouse the opposition of all the rest.

CITY AND GUILDS OF LONDON INSTITUTE.

The results of the May Examinations under the direction of the City and Guilds of London Institute for the Advancement of Technical Knowledge show an improvement which, though not very considerable, is steady, uniform, and on the whole satisfactory. The centres of instruction and examination appear to be multiplying, and the average of pupils attracted by these facilities and encouragements is increasing at the rate of about five hundred per annum. About half of the total number of students usually present themselves for the annual Examination, and, roughly speaking, half of these latter succeed in satisfying the Examiners. The proportion of failures is still far too large; but it may be confidently expected that, with the increase in the number of trained and competent technical teachers, the quality of the instruction will improve, and its results come out better under the test of independent Examiners. Of the total number of candidates examined nearly sixteen hundred presented themselves for the first time. The tables printed in the report before us, besides being wanting in descriptive headings, and puzzling in their arrangement, are defective in respect to candidates who having failed on previous examination have come up again, or have abandoned the attempt altogether; but of those who had passed in 1884 only three hundred and fifty-eight have advanced this year into a higher grade, a fact which seems to point either to stiffer papers or looser instruction. The report, however, expresses satisfaction on this and the general results, and we may be mistaken as to the significance of the figures. As regards the comparative number of passes, we also fail to see the point dwelt upon in the secretary's opening remarks. There were, it appears, 333 more candidates this year than last, whilst the increase of passes was 339. "Thus," says the Report, "the increase of passes is six more than the total increase in the number of candidates." As a statement of fact this is indisputable, but it is unimportant. If they related to new candidates only, the figures would be striking; but in reality nearly 600 examinees had gained passes, and many more, no doubt, had all but gained them at last year's Examination. Still, what would an annual report be good for if not inspiriting, or a secretary if not a dab at figures?

The point on which we are disposed to dwell with greatest satisfaction is the large estimated increase in the number of students who will this year gain their full Technological Certificates. Representing as it does a qualifying certificate in Science from the Science and Art Department, as well as that in Technology, the full certificate indicates a determination to pursue these studies with a serious aim; and the addition of 750 in the present year to the 566 of last year is a substantial gain which the promoters of technical education have reason to be proud of. From the list we published a fortnight ago it will be seen that the subjects most interesting to our readers have received a fair and increasing share of distinction. Outside London, Manchester carries off the palm in these, as in other items of technical training, having obtained the silver medals both for Electric Lighting and for Telegraphy. In the metropolis Electric Lighting attracts a greater number of students than follow it elsewhere; but this can hardly be said of Telegraphy, which appears to be much sought after and admirably taught in the provinces—notably, at Manchester and Dublin. At the last-named place a school, described as the Postal Telegraph Office, has obtained eleven passes, with four Honours and a bronze medal. A similar school connected with the Central Telegraph Office, London, however, has received the same number of Honours, with two bronze medals, and ten passes. All the results obtained at Manchester in respect to Electric Lighting and Telegraphy are credited to the Technical School at that place. In Electro-Metallurgy the few passes obtained go chiefly to Birmingham. Compared with the achievements of the provincial Institutes those of the Finsbury Technical College in London do not shine very brilliantly, numbering in all only twenty passes for Electric Lighting, five for Telegraphy, and two for Electro-Metallurgy. Considering the resources of the parent establishment, this may excite some surprise; but if the passes bear a due proportion to the number of pupils, as no doubt they do, the result only shows that the demand for technical instruction in London is, taking the size of the metropolis into account, far less than in most of the great manufacturing towns.

We should have been glad to have more information as to the avocations of the pupils who avail themselves of the educational privileges afforded by this great scheme of technical instruction, so that we might draw some conclusions as to its probable effect on the work of the future British artisan. That it will encourage and develope the taste for scientific pursuits, and promote the acquisition of accurate technical knowledge we have never doubted; and these things, being good of themselves, are well worth the cost. But we could not fully share the hopes with which the movement was inaugurated—hopes, namely, that British industry would beat its foreign rivals if the British workman were more highly skilled; which when put into plain English meant that if he could be made cleverer he would be better worth his high wages. No doubt of it; but in the workman's opinion he would be worth higher wages still; and he is not likely to make the sacrifices which hard learning entails unless he has a motive in the shape of higher reward. It is not in that way, or in any other way that we know of, that the inequalities of wages in different countries can be levelled. When workmen educate themselves it is to promote inequality in their own persons—in other words, to get on better than their fellows; never to compete with the foreign market. It is for their masters to do that, and chiefly in that direction may we look for the improvement we desire. Higher technical education for employers and their head-men is what is needed most, and this is what will pay best. We do not mean that the workman's technical education is a matter of no importance; what we do mean is that we need not despair or be greatly surprised if he is slack in acquiring it, supposing there is no spare wages fund from which he can be remunerated for his trouble.

CORRESPONDENCE.

METHOD OF EQUALISING THE CHARGE IN CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is a common practice to cut out any cell or cells in an accumulator which appears to be charged before the remainder, and to continue charging the others.

In fact, the E.P.S. Company advise this course in their instructions. I have always employed another method of equalizing the charge in the cells, which has proved very successful, so I think it right to place it before your readers, since I observe that it is not mentioned in the most recent instructions sent out by this company.

The process consists of "short-circuiting" any cell which appears to be overcharging through a resistance during a part

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or the whole of the time of charging the cells. A very small resistance is sufficient, because the E.M.F. of the cell is only 2 volts approximately. To give an example:—Suppose an accumulator is charging at 30 amperes, and the E.M.F. of a cell at the time to be 2·3 volts. Then, if any cell is short-circuited through 0·077 ohm, it is clear that the cell is discharging as fast as it is being charged, and therefore its "contents," or rather "chemical state," remains stationary, whilst the others continue charging.

Any other resistance might have been used, according to the requirements of the case. This method is more convenient and scientific than the disconnecting process generally employed, which is troublesome and dangerous, unless spanners with wooden handles are used; and indeed no metal spanners should ever approach the cells, for fear of making accidental short-circuits when turning the "nuts."

Some curious points may be observed when a cell is short-circuited as described:—

1st. That the current which traverses the resistance is apparently the same, whether the cells are charging, discharging, or stationary.

2nd. That the usual laws relating to divided circuits apparently no longer apply.

3rd. That the current traverses the whole of the cells, and yet is apparently annihilated at the short-circuited cell. I say *apparently*, for these phenomena are not real when examined.

There is another point connected with cells which seems not to have been noticed. When the plates are fully charged the positive plates (E.P.S. Co.) begin to whiten, and they do not regain their dark colour till slightly discharged. At the moment of being fully charged the E.M.F. is very high; in a few minutes it falls, but rises slightly where the plates become darker.

I have observed this again and again, and now take this "whitening state" to indicate the time to stop charging, apart from the usual tests. All these tests seem to agree together when the plates and acid are new, but after a time the "boiling" and "specific gravity" tests do not appear to agree completely with the charge in the cells.

I have reasons for supposing that if the charging is habitually carried too far, this white coat gets too thick to disappear, and even if the plates are not injured, the E.M.F. of the battery falls permanently until the coating is rubbed off. I hope that others may make observations on this point and publish them. The question is, What is this white substance? Theoretically, it should be PbO_3; but I am not aware that such a substance can exist. Hence, since there is every probability that the process is one of oxidation, and as sulphur is present in the acid the white layer may consist of $PbSO_4$, which is not soluble, and therefore care should be taken to avoid more forming than possible. The process of charging removes small quantities, but I doubt if it is of any avail if the plates are *completely* and *thickly* coated.

Moral: Do not habitually overcharge.

I might be tempted to say more, but I feel to have trespassed too much upon your space already.—Yours, &c.,

DAVID SALOMONS.

Broomhill, Tunbridge Wells, August 24, 1885.

RESISTANCE OF VOLTAIC CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Dr. G. Gore's experiments (*see* p. 279) on the apparent variation of resistance of voltaic cells according to the current passing are very interesting to me as in a manner explaining the extraordinary results I used to obtain (some fifteen years ago) when measuring the resistance of Leclanché cells. When small resistances were in circuit a cell generally gave about 3 or 4 ohms, but if a large resistance x were inserted, the result was not $x+3$ or 4 ohms, but more likely $x+30$ or $x+300$, according to the resistance inserted, of course on the assumption that the E.M.F. remained constant. As two distinct observations with different strengths of current had to be made to get at the apparent resistance, the results were quantitatively almost useless, when they were used to find out the cause of the thing, especially as the E.M.F. of this kind of cell is very variable.

Would it not, however, be better to express the results in terms of volts than in ohms; for instance, to say that in the case of Cd and Zn (first example, Table I) the back E.M.F. at the negative plate is increased by ·0136 or by ·035 volt (assuming that at the positive plate to be constant), with given currents passing, or that the total E.M.F. of the cell is reduced by these amounts?—Yours, &c.,

OLIVER HEAVISIDE.

HISTORY OF THE INCANDESCENT LAMP.

For several years past the question has constantly presented itself whether the electric light was destined to supplant the artificial sources of light hitherto in use, especially that of gas light, and to be looked to as the only means of illumination for the future. For a long time it appeared in certain circles that the answer to this question must be unfavourable to the electric light. Among other objections, it was pointed out that electric illumination—the mass of the public understood this to indicate only those arc lights which were as yet alone in practical use—suffered from an *embarras de richesses*, for the powerful rays of the electric lamps, from their great intensity, were only suitable for large areas, while for general and domestic purposes gas still appeared the most suitable means of illumination. It is true that for the requirements of general practice a tolerably adequate subdivision of the light may be considered practicable, and the electric light produced by arc lamps can now be subdivided to intensities of from 10 to 20 gas jets. But in the first case the minimum of such a subdivision is still a great deal too high for many purposes, especially for domestic use, and again, so extended a subdivision requires a regulating mechanism which is proportionately so expensive that, as far as cost is concerned, electric light can under these circumstances make no competition with gas. Such being the case, it was of the highest importance to obtain a lamp by which electric lights of a much lesser brilliancy could be produced without any regulating mechanism, at least with a minimum intensity of a single gas jet.

But in this sphere there were many errors and delusions to be contended with before a practically satisfactory result could be obtained. The history of the incandescent lamp may well be called a history of errors in the sphere of electrical investigations, and, in spite of the scientific importance of such investigations, there is a comic side to the picture presented to the curious student of the story of the development of incandescent lamps.

The great problem to be solved was to discover a good conductor of electricity which could neither be consumed nor volatilised in a vacuum. Now came an eager quest after the treasures buried in the deep recesses of scientific knowledge, to obtain which each young enthusiast in natural science felt himself called. American capitalists were the first to provide the necessary funds for the development of an idea from the realisation of which a golden harvest was justly expected.

Starting on the principle that all roads lead to Rome, attempts were made to utilise the most manifold and various ways and means to attain the end in view, till the conviction established itself that practically there were only two substances in existence possessing to a satisfactory degree the properties absolutely essential to an incandescent lamp, and these were—first, platinum or an alloy of platinum and iridium, and, secondly, carbon. Platinum presents this advantage compared to carbon, that it can be brought to a white heat without being consumed in air, a property rendering this metal eminently suitable for the requirements of incandescent lamps; but in another not less important particular platinum stands far behind carbon, for it cannot stand, without melting, at anything approaching so high a temperature. But where incandescent lighting is concerned, the incandescent substance must be capable of enduring an excessively high temperature.

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This circumstance has also an important bearing from an economical point of view, inasmuch as the light obtained from any glowing substance increases in a much more rapid ratio than the temperature of the material employed. For instance, if a piece of platinum wire or carbon thread is heated to redness, an almost inappreciable amount of light is produced, but if the temperature be doubled by allowing a corresponding increase of current to pass along the conductor, more than twice the very slight amount of light previously obtained is produced. It is consequently indisputable that the higher the temperature to which the incandescent substance is raised the less expensive is the energy absorbed to produce the light. Carbon or metal? Herein lay the great question which for ten years occupied the attention of every thoughtful electrician.

We shall here present a brief survey of the more important points of the above-mentioned movement, and dwell for a longer time only on the more prominent intellects, such as De Changy, King, Starr, Lane-Fox, Edison, and Swan, and submit their labours and successes to a closer inspection.

To Professor Jobard, of Brussels, is due the first impulse towards the most important of investigations on the subject of incandescent lamps. He suggested in the year 1838, in the *Courier Liberal*, the idea that a small piece of carbon, acting as conductor of a current in an exhausted receiver, would give an intense, steady, and continued light. Herr Jobard advised his future pupil, De Changy, to undertake the development of this idea. De Changy applied himself to these investigations all the more readily that, as a mining engineer, he hoped to be able to open out a wide field for incandescent lighting in mines. After some theoretical preliminaries De Changy began his work in 1844, an Englishman named Moleyns having previously, in 1841, made the first experiments with platinum incandescent lamps. For incandescent material he employed small splinters of gas carbon. These he enclosed in an exhausted glass receiver, and put these in connection with his conductors. To add to the consistency of the carbon, he attempted to fill its interstices by saturating the pieces with molten resin or sugar solutions, and then allowing them to solidify. The result obtained was, all things considered, a success, and De Changy proceeded to the construction of the first incandescent lamp. But thus was forged the first link in that chain of vanished illusions running through the history of the development of incandescent lamps. The experiment failed, first, because the piece of carbon was disintegrated by the current; and, secondly, because the electrical energy absorbed in the production of the light, and the amount of heat generated in the relatively massive carbon were very great. Besides, the imperfect sealing up of the lamp and exhaustion of the air allowed the carbon to be partially consumed in the oxygen of the air. A great part of the electrical energy was necessarily lost for production of light by conduction of heat and currents in the imperfectly exhausted air. Soon after this certainly encouraging result the appointment of De Changy as principal managing engineer of the Wedl-Ocean and Wedl-Ramoth mines caused a long interruption to his interesting investigations and experiments.

(To be continued.)

THE DEFORMATION OF THE LUMINOUS WAVE SURFACE IN THE MAGNETIC FIELD.—The results of this investigation are summed up by E. von Fleischl, as follows:—1. That the wave surface in the magnetic field has undoubtedly in general the form described by him of two surfaces of rotation which intersect one another. 2. That the form of these two surfaces differs to an extremely small extent from the spherical form; but that notwithstanding 3. The spherical form of both parts of the double surface which results from Verdet's law of the cosine, and which with this law is implicitly assumed in all previous inquiries, is only a faint approximation to the true form. And 4. That the form of the wave surface in the magnetic field is a double surface made up of two ellipsoids of rotation, which are so displaced in the direction of their greatest axes that they nearly coincide with each other.

CUNYNGHAME'S MEASURING INSTRUMENT.

We herewith illustrate an ammeter, consisting of a soft iron armature, mounted on an axis between the poles of an electro-magnet, and controlled by a spiral spring, the angle of torsion of which is measured on a dial by a pointer attached to a torsion head carrying one end of the spring.

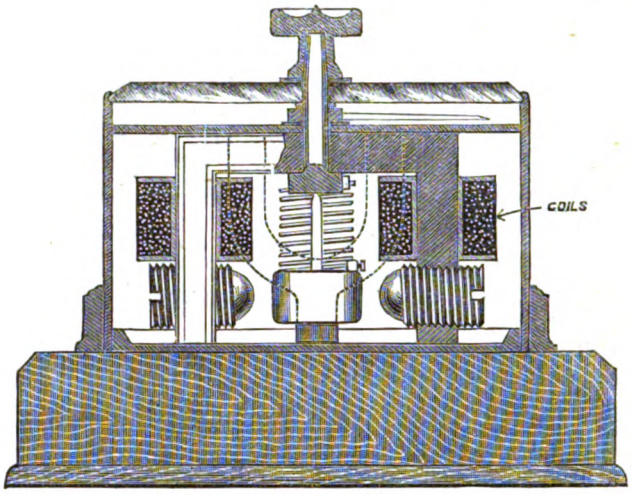

FIG. 1.—Patent Ammeter and Voltmeter. Sectional Elevation.

When no current is passing, and the torsion head pointer is at zero, the armature rests obliquely across the lines joining the poles of the magnet, and its pointer also rests at a zero mark. As soon as a current passes through the coils the armature is dragged by the magnetic force to a position length-

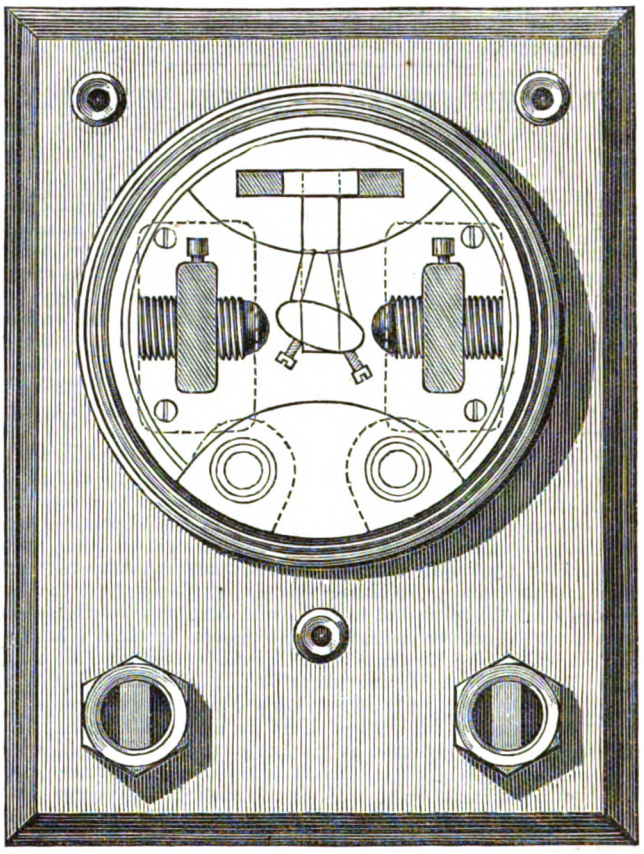

FIG. 2.—Sectional Plan.

wise between the poles of the magnet. The spring is now twisted by turning the torsion head by hand until the position of the armature is shown by its pointer to be the same as before. Then, since the magnetic force acting on it varies as the square of the current, and is balanced by the torsion of the spring, it follows that the tension of the spring is also equivalent to the square of the current. But the

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tension of the spring depends on the angle through which it is turned, and therefore the square of this angle varies as the current. The dial is therefore marked with divisions representing successive amperes, which proceed as the squares of the numbers indicated on them; and by means of the movable pole pieces the magnetic force is easily adjusted to suit the dial. The form of the instrument is shown in Figs. 1 and 2. It measures about 8in. long by 6in. wide, and may be placed either in a horizontal or vertical position. The voltmeter must be used horizontally.

The advantages claimed for these instruments by Messrs. Woodhouse and Rawson, the makers, are :—

1. While possessing the accuracy of a Siemens dynamometer, they are readily portable, having no mercury cups, and may be fixed in any, although it is advisable to have them in a horizontal, position.

2. They do not depend on mercury contacts, so that the circuit is absolutely unbroken.

3. By reason of the strength of the spring they are almost dead beat.

4. The horse-shoe magnet and armature form together a closed circuit, so that they are not appreciably affected by outside magnetic influences.

5. They do not depend on permanent magnets, which are very variable.

6. They read amperes direct on a dial, instead of requiring a table of angles and current strengths.

7. They are adjustable by means of the movable pole-pieces, so that the same instrument may be readily set in order by one comparison with a standard instrument, and no calibration is required. Any instrument can by the like adjustment be made to register currents even double as great as those for which it was constructed.

By winding the magnets with very thin wire, voltmeters are constructed for which the same advantages are claimed as for the ammeters.

ARC LAMPS COUPLED PARALLEL WITH INCANDESCENT LAMPS.

Mr. Schuckert, the well-known dynamo engineer, has sent us for publication an article on the question of working arc lamps and incandescent lamps off the same circuit in parallel connection. Although the subject is not new, Siemens, Gülcher, Crompton, and others having already for some time adopted this method of working, Mr. Schuckert in his article explains the matter so very clearly that we think a short abstract of his remarks may be interesting to our readers.

In many cases, especially in mills and factories, it is necessary to employ both arc and incandescent lamps. If the installation is not sufficiently large to justify the employment of two separate dynamos, one for the arc lights, the other for the incandescent lamps, it is very desirable to find a method whereby both kinds of lamps can be fed from the same circuit independently of each other. It is also sometimes necessary to employ arc lamps of different power in the different parts of the same installation, a condition which can evidently not be fulfilled by the usual arrangement of putting lamps in series. One method of accomplishing this is by placing all the lamps in parallel connection, but in this case a comparatively large resistance must be inserted in each branch circuit, entailing a heavy loss of electrical energy. The reason for this will be obvious if we consider what would happen if arc lamps and incandescent lamps were coupled parallel without any resistances in the arc circuits. The pressure required for an arc lamp is about 43 volts. Let us assume that the dynamo is perfectly self-regulating, and able to maintain this pressure at its terminals, no matter how the total current may vary. If now, through impurities in the carbons, the resistance—or, to speak more correctly, the apparent resistance—in one of the arcs were to increase slightly, the current through that arc will slightly diminish. If the lamp does not regulate immediately—that is, if the length of arc remains unaltered for ever so short a time—this would still further increase the apparent resistance, and the arc would be broken. There is no lamp as yet in the market which can follow with sufficient rapidity the variation in current to save the light from temporary extinction when working under such circumstances. As soon as the arc is broken the carbons run together, and for an instant the main leads are thereby short circuited. This lowers the pressure on the other lamps, which in their turn lose their current and go out. Whilst the first lamp recovers, the carbons of one of the other lamps come in contact, thus extinguishing again all the rest. Under these circumstances it is impossible to obtain a steady light. To overcome the difficulty, it has hitherto been found necessary to fix the pressure at 65 volts, and to insert with each arc circuit sufficient resistance to bring the pressure at the lamps down to 43 volts. To avoid this comparatively heavy loss of 22 volts it is now customary to place two arc lamps in series, and each series in parallel with the others and with the incandescent lamps. This arrangement has in the first place the advantage of reducing the influence the disturbance in one lamp may have on the whole system. It also lessens the disturbances in each lamp, since the other lamp coupled in series with it acts to a certain extent as a steadying resistance. To make this system successful it is necessary that the regulating mechanism of each lamp should be exceedingly delicate, and that it should act quickly yet gradually. Mr. Schuckert recommends for this purpose the Piette-Krizik lamp, which, when so coupled, only requires 43 volts to give a steady light. The additional resistance required in each branch is therefore exceedingly small, and a loss of only 10 volts out of 100 is incurred.

We may add to Mr. Schuckert's remark that results nearly as satisfactory as these are commonly obtained in England with a number of differential lamps. The pressure between the mains is generally fixed at 110 volts, and each arc lamp is regulated so as to require from 45 to 47 volts. The pressure utilised in the lamps is therefore about 92 volts, out of 110 volts generated.

THE INTERNATIONAL TELEGRAPH CONFERENCE.

Mr. M. Smith, the Victorian Agent-General, has arrived at Berlin, and will represent Victoria during the further deliberations of the Conference.

At a plenary meeting of the Conference, on the 22nd inst., the resolutions of the Tariff Committee were discussed and approved in such a form as entitles one to say that the proposals of the German Postmaster-General for the introduction of a reduced and uniform European tariff were adopted to about half their original scope and extent, but that is all. Of twenty-five delegates representing States, twenty-one voted in the affirmative, while four refrained from voting on the ground of want of instructions. England, Russia, France, and Austria were among the ayes. Stated in brief and general terms, the result of the decision is simply this, that what is called the "grundtaxe," or fixed primary charge on all telegrams, irrespective of the price per word, will be abolished, and that henceforth, therefore, the tabulated word tariff under the European Telegraph Convention will represent the real, as well as the apparent, price of messages. Some States, however, Germany for example, reserve to themselves the option of imposing this grundtaxe (so as not to lose on small messages), but yet in such a manner as shall not raise the cost of a telegram above the total amount of the simple word charge.

Another important result of the resolution is that what is called the terminal tax, or share of charge on telegrams falling to the country of receipt, will be reduced and regulated—the large States receiving 10c. per word, smaller ditto 6½c., and Russia, which insisted on a special arrangement in her favour, 30c. Germany had proposed 8c. and 4½c. for the larger and smaller States respectively. In like manner, transit dues, or share of cost falling to countries through which a message merely passes, are to be fixed at 8c. for the large States, 4c. for the smaller ones, and 24c. for Russia. Russia and Turkey to be allowed to impose an additional rate in consideration of the difficulty of maintaining long telegraph lines through extensive and partly uncultivated districts. Where there is more than one telegraph line between two points, the rate for the cheapest to be invariably made irrespective of the route by which the telegrams may have been actually forwarded.

Our contemporary, the *Colonies and India*, says :—The Australian delegates have had no difficulty in presenting a strong case. According to Mr. Heaton's figures the 10s. 8d. now received for every word in cable messages is distributed as follows :—

	For conveying the message.	Miles.	
The Eastern Company get ...	3s. 1d.	6,479	London to Bombay.
The Indian Govnmnt. get ...	0s. 8d.	650	Bombay to Madras.
The Eastern Exten. Co. get..	5s. 8d.	3,862	Madras to Port Darwin.
The South Aust. Gov. get ...	1s. 3d.	2,100	Port Darwin to Adelaide.
	10s. 8d.	13,091	

The Indian Government charge is a monstrous one, particularly as they only charge about 1d. per word over the same wire for a local message. The income from Australasian business is nearly £300,000 per annum (including a subsidy of £30,000 per annum), and the Australasian business has doubled itself in ten years. A private meeting of those interested has taken place, with the result

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that the cable companies have offered to reduce the charges by 2s. 6d. per word, or a total of 8s. 2d. per word to the public, and convey cable messages for quarter rates, or a total of 2s. 8d. per word from England to Australia. This is a most substantial reduction, and is likely to give great satisfaction to the colonies. But it is not quite settled yet. The consent of India and of South Australia has to be obtained.

LIGHTHOUSE ILLUMINANTS.

The Select Committee appointed by the Trinity House to inquire into the relative value of oil, gas, and electricity as illuminants for lighthouses have drawn up their Report, from which we print the following particulars, published in *The Times* of Thursday, the full Report not being issued to the public for some days to come :—

The gas system had been developed chiefly in Ireland, while the lighthouses on the English and Scotch coasts were illuminated mainly by oil. To make a general change from oil to gas would have involved a very heavy cost, which the Elder Brethen and the Board of Trade evidently demurred to, they being of opinion that the oil light was sufficient for the purpose of the mariner.

The question, therefore, had to be submitted to the practical test of experiment, whether it was worth while to incur the great expense of altering existing oil lights for the sake of replacing them with either electric or gas lights. In this question mariners and shipowners are deeply interested ; in the one case safety and speedy navigation are largely dependent upon the efficiency of the coast lights ; on the other hand, the shipowner, though desirous of having the best lights for the protection of his ships and their cargoes, is not willing to pay more than is absolutely essential for the maintenance of good lights.

In arranging for carrying out the experiments, the Trinity House Committee had under their consideration two broad divisions of the whole subject—viz. (1) the lights to be exhibited, and (2) the observations to be made upon those lights. In selecting the South Foreland as the site for the trials the committee were influenced by both these considerations. The establishment already there for exhibiting electric lights in two permanent towers afforded the requisite motive power (steam) for working experimental electric machines. The position afforded a wide range for observations from seaward, and the general face of the country, without trees and hedges, gave facilities for setting off tracks along which the lights could be kept continously in view for distances under three miles, if the state of the atmosphere permitted, and provided the means for making measurements and observations requiring a shorter range and steadier base than are attainable at sea.

Three experimental towers were put up, lettered respectively A, B, and C ; the first (A) appropriated to electricity, the second (B) to Mr. Wigham's gas system, and the third (C) to oil and occasional gas lights. The towers were separated from each other by a distance of 180ft., which was found sufficient to prevent the blending of the light at long ranges.

The lantern surmounting each tower was 16-sided, having five sides glazed towards the north and four towards the south. Those for A and C were identical in shape and size, and were constructed at the Trinity House workshops at Blackwall. That for B tower had the same diameter as the others, but not the same height, being shorter by a few feet. It was supplied and fitted by Mr. Wigham to suit his quadriform gas system.

Each lighting system was adapted to be shown in multiform arrangement, *i.e.*, with lights placed vertically, one above the other, it being believed that the great body of light so produced is effective in thick weather. For gas, provision was made for showing, simultaneously, four such lights—quadriform, as the arrangement has been termed ; while for the electric and oil systems provision was made for the exhibition of only three superposed lights—triform. There appears to have been some apprehension that it might not be possible to exhibit with safety more than three mineral oil lights in the vertical space available in the lantern, the superposing principle being to some extent a novelty in lighthouse illumination with mineral oil. To Mr. Wigham is due the chief credit for the development of this principle in respect of his gas lights, and the splendid column of light produced by his quadriform arrangement may have suggested the desirability of applying the system to oil-burners. The question of patent right in respect of the superposing principle was in an unsettled condition at the commencement of the trials, but it has since been finally set at rest, and any cause of dispute on this point has thus been eliminated from the inquiry. It is stated as one of the results of the experiments that there is now no doubt "it is possible to exhibit either of the two systems (gas and oil) in a lighthouse under precisely similar conditions as to vertical distance between the lights."

It will now be understood that in the A and C lanterns of 19ft. in height, the three lights were separated by much greater vertical spaces than the four lights in B's lantern of 17ft. ; while, on the other hand, an endeavour was made to compensate to some extent for this defect by the use in the C lantern of larger lenses for the production of the revolving beams than those employed in B tower.

Inside the lanterns, at the proper focal distance from the lights, and mounted on circular rotating tables, were portions of lenticular apparatus such as are employed in lighthouses. These optical aids were of two kinds—one adapted for showing a periodic revolving beam, the other for showing a continuous fixed light—and were at the outset of the experiments special in relation to the illuminant with which they were to be used. The small but intense electric arc was provided with the optical apparatus considered to be best suited to it. It consisted of a panel of the apparatus for a second order fixed light with the external addition of vertical prisms, so that the rays, being parallelized in both the horizontal and vertical planes, issue as a condensed beam. With a 12-sided apparatus, twelve beams would issue forth ; and if the apparatus were rotated, successive beams would pass by at regulated intervals. But one panel only was sufficient at South Foreland to illustrate the effect of the revolving beam of an electric light. Gas, with its far larger flame, had large annular lenses forming part of the revolving triform apparatus intended for the new lighthouse on Mew Island, on the Irish coast ; and oil had still larger annular lenses of the type adopted at the Eddystone lighthouse, which, it was apparently anticipated, would compensate for the absence of the fourth superposed light. These annular lenses condense the incident light into a beam of parallel rays, and when set in motion by rotating the framework on which they are mounted, present to the observer the appearance of a revolving light. The lenses provided for exhibiting fixed lights were the same in all—*i.e.*, panels of an all-round lenticular apparatus—except that the electric light was furnished with lenses of the second order, while those for gas and oil were of the first order. The upper and lower prisms usual in apparatus for fixed lights were not provided.

For each light in superposed arrangement a pair of lenses was appropriated to show as either a revolving or fixed light ; thus the electric had three panels of revolving and three of fixed apparatus ; the gas had four panels (annular lenses) of revolving and four of fixed apparatus, and the oil had three panels (annular lenses larger than those in the gas lantern) of revolving and three of fixed apparatus.

We now come to the lights exhibited. In the electric tower three regulators or lamps of the Berjot type were used, one on each tier. The carbons in use have been varied several times. The "fascine" or bundle carbons, supplied by Baron de Meritens, were tried, but they did not give satisfactory results. Siemens's carbons of 20, 30, and 40mm. were much used, some having a core of graphite in the centre. All were circular in section except the "fascine" pattern, which were square. The three magneto-electric machines which furnished the illuminant for this tower were fixed in the engine room of the establishment 800ft. distant from the tower, in convenient positions for the application of steam power. The machines were supplied by Baron de Meritens, of Paris. Each contains 60 permanent magnets, of horseshoe form, eight laminated pieces to every magnet, the whole disposed in five rings of 12 magnets each and associated with five discs revolving within them, each having 24 coils on its outer ring. The machines are worked at a speed of about 600 revolutions per minute. Such powerful arc lights as those produced by these machines have never before been exhibited in this country.

The exhibition of the experimental lights was commenced in the spring of last year. It now becomes necessary to refer to the means adopted for observing the effects of these various lights.

It has been stated as one of the reasons why the South Foreland was selected for these trials that the nature of the adjacent country afforded facilities for observing the light at distances under three miles. This was naturally of advantage in thick weather, and from the towers a line was marked off with posts, 100ft. apart, to observation hut No. 1, distant 2,144ft., or nearly half a mile. The undulating character of the ground made it necessary to take up the line at another point, but at the same distance from the towers as hut No. 1. From this point the line was carried with one divergent break to hut No. 2, distant from the lights 6,200ft., or nearly a mile and a quarter. From this hut another divergence had to be made, the line being picked up at the same distance from the lights as hut No. 2, and carried without break to hut No. 3, distant two and a half miles. Along all these lines the lights were fully visible in ordinary conditions of weather, and observers were stationed at the huts in order that nightly observations of the lights should be recorded. The members of the committee and officers of the Trinity House, together with numerous distinguished visitors, made frequent use of these lines of posts and the huts. For observations at greater distances, the services of the Coastguard between the North Foreland and Dover ; the lightsmen on board the "Gull," the "Goodwin," and the "Varne" light vessels ; the lighthouse keepers at the North Foreland ; pilots and masters of vessels navigating in the vicinity ; and the Elder Brethren of Trinity House and their officers, at various times and distances at sea and on land, were called into requisition. The observations so recorded have been classified as eye-measurements—that is, those made by the naked eye unassisted by instruments ; another classification, of which we shall speak presently, is that of observations made by photometry. According to a tabulation given in the report it appears that upwards of 6,000 observations have been recorded, of which for various reasons it has been found necessary to reject 1,946, leaving more than 4,000 available for analysis. Four tables are given indicating the results obtained by analysis of the recorded observations. Table I. shows the result of comparing the electric light with the highest powers of gas and oil, both as revolving and fixed lights. Seven hundred and fifty-four observations made at various distances and in all kinds of weather are taken, the analysis of which shows that the electric light, under all conditions of weather, has a superiority of about 35 per cent. over the quadriform gas with 108 jets, and about 40 per cent. over triform oil, six wicks. Probably the percentages are in reality much higher than these, but it is difficult to assign even an approximate numerical value to lights by eye measurement. A note to this table states that, although there are upwards of 3,000 other observations in which the lower powers of gas and oil are compared with different powers of the electric light, it is thought sufficient to show the result of comparing only the highest powers of gas and oil with the electric light. This table is apparently regarded as definitely establishing the superiority of the electric light, and accordingly the following tables are devoted to direct comparisons of the gas and oil lights. Table II. gives an abstract and summary of observations at various distances upon comparison of the

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different powers of Wigham's gas burners with the Trinity House 6-wick oil burners—(1) in clear weather, (2) in weather not clear. The summary of this table indicates that in all kinds of weather quadriform gas revolving lights with 68, 88, or 108 jets are rather better than triform oil revolving lights (six wicks); but that when the lights compared are equal in number. the difference is hardly perceptible. For fixed lights in all kinds of weather the gas lights are superior. Table III. gives some results of comparing single lights when shown through lenses of equal size, and also a comparison of the large Eddystone lenses used in C tower with the smaller Mew Island lenses used in B tower. A very small percentage of superiority is recorded for the 108 jet and 88 jet gas burners over the 6-wick oil burner, and a slight superiority of the large Eddystone lens over the Mew Island lens.

Table IV. gives the average recorded values of the Wigham gas-burners as compared with the six-wick oil burners at distances varying from half a mile to 15 miles in weather not clear but without absolute fog. In an aggregate of the whole of the observations in this table the result is generally in favour of quadriform gas; but it is noticeable that, as the distance increases, the difference between quadriform gas and triform oil is less and less apparent. The Committee state that it would require a much more decided and constant superiority to justify them in giving either an unqualified preference, except as regards lights in the fixed phase, when the superiority of the gas is definitely established.

In continuation of the eye measurements one section of the report is devoted to the important subject of the fog and mist. Each experience of fog or thick mist is described in detail. The records are at times of a highly interesting character, and a summary of the results of the observations is given after each fog report. If these are followed through it will be found that electricity is, with one or two exceptions, the reason of which is explained, more effective in fog than either the gas or oil lights. There is an interesting variety in the observers as well as the mode of recording; but the summary in each case is matter-of-fact and judicial. The most noticeable feature about these fog reports is the exceedingly short distances at which these most powerful lights are visible in thick fog. The bulk of the observations are made within a distance of 2,000 feet, and the superiority of the electric light is determined by possibly two or three hundred feet, or less, while the gas and oil lights at full power are practically equal. For purposes of navigation in foggy weather a difference in the visibility of lights of two or three hundred feet is of no value whatever, and the conclusion is inevitable that the most powerful light exhibited is useless in a fog. Glare and flare alike seem to be unavailing, bonfires or electric arcs, diffused or condensed lights, are all obscured by fog within a very short distance from one another. But in weather not absolutely foggy, when the normal range of the lights is lessened by haze, the evidence given by these observers indicates that the electric light is seen further than the gas and oil lights, and that its superiority at such times is of real practical advantage to the mariner. It was a little unfortunate that, to quote the Committee's words, "the year in which these experiments have been carried out was marked by a singular prevalence of clear weather;" but, nevertheless, the experiences obtained are valuable, and form an important contribution towards the settlement of a vexed question.

TABLE A.

Burner.	Illuminating Power of Naked Light.	Illuminating Power through Lens in Clear Atmosphere.		
		Cylindrical Belt and Vertical Prisms.	Eddystone Lens.	Mew Island Lens.
Electric, 1 machine.....	10,000	1,250,000	—	—
Electric, 2 machine.....	15,000	1,500,000	—	—
Douglass, 10-ring, gas...	2,500	—	105,000	94,000
Douglass, 6-ring, gas ...	825	—	92,000	70,000
Wigham, 108 jet, gas...	2,300	—	—	59,000
Wigham, 88-jet, gas ...	1,400	—	—	54,000
Wigham, 68-jet, gas ...	990	—	—	48,000
Wigham, 48-jet, gas ...	680	—	—	42,000
Wigham, 28-jet, gas ...	250	—	—	33,000
Sugg, 6-ring, gas.....	820	—	55,000	—
Siemens, gas.....	600	—	10,000	—
Douglass, 7-wick, oil ...	950	—	60,000	49,000
Douglass, 6-wick, oil ...	730	—	64,000	48,000
Service, 4-wick, oil.....	415	—	55,000	44,000

We have now to consider the means adopted for measuring the lights with more exactness than could be accomplished with the unassisted eye. In this branch of their inquiry the Committee, besides having the advantage of the advice and assistance of Mr. A. G. Vernon-Harcourt, F.R.S., who watched the experiments on behalf of the Board of Trade, had retained the services of Mr. Harold Dixon, M.A., of Balliol College, Oxford, whose experience in matters relating to photometry is considerable. To this gentleman was intrusted the duty of making photometric observations on all the lights submitted for trial. These operations were carried on at the observing huts Nos. 1 and 2, and at the photometry gallery, a building 280ft. long by 8ft. wide, with all appliances for exhibiting any of the lights under trial, with or without lenses, under conditions convenient for direct measurement. Sir James Douglass, besides assisting in the preliminary consideration of these arrangements, adapted some of the instruments ordinarily used in lighthouse work for the special service in view. A detailed description of the various apparatus employed is given in Mr. Dixon's report, and partly in the text of the Committee's report. It will be sufficient here to state that the Harcourt pentane standard flame was chiefly employed in these measurements, though occasionally the flame of a mineral oil Douglass burner, enclosed in a lantern fitted with slides on the Methven principle, so as to enable the visible area of the emerging light to be adjusted to the value of two, four, eight, or any convenient candle-power in accordance with the pentane standard, was employed, and was found to be very serviceable on windy nights when the pentane flame was rendered unsteady.

Mr. Dixon, at the outset, classes the questions submitted to him for determination by photometry under four heads:—(1) What is the total unaided light given by each of the illuminants submitted to trial, and what is the "efficiency" of each? (2) What is the light given by each illuminant through the optical apparatus designed to show it—first, as a revolving light, second, as a fixed light? (3) What is the relative value of superposed lights in each system? (4) What is the relative illuminating power of each source of light under different conditions of weather?

The first two questions are answered chiefly by tables of measurements in which the order of merit of the various burners is stated with exactness. The preceding Table A gives the candle-power of each illuminant not superposed, with and without the optical apparatus designed to show it as a revolving light.

As regards Question 3 Mr. Dixon's conclusion is that "multiplied lights are superior to single lights in penetrative power at all distances beyond the point where the separate lights begin to blend together in the eye. This point is about half a mile from the lights in A and C towers, and less from the lights in B." He further states that "actual experience in fog and hazy weather leaves no doubt of the utility of the multiform arrangement with gas and oil lights at all distances beyond half a mile. In the case of the electric light the greatest visibility is secured at short distances by sending the current from one or more machines through a single arc."

To Question 4 Mr. Dixon replies that oil and gas lights when shown through similar lenses are equally affected by atmospheric variations, and that the electric light is absorbed more largely by haze and fog than either the oil or gaslight. The Wigham 108-jet gas burner has an advantage of 16 per cent. over the 6-wick oil-burner in all weathers where both are shown through equal lenses, but this means but slight difference in penetrative power. "In many observations, both on sea and land, in haze and in thick fog, the quadriform 108-jet gas light was picked up just before, but only just before, the triform 6-wick oil light; in other observations the two lights were picked up simultaneously." Mr. Dixon also concludes that in all weathers and at all distances the electric light, whether shown as a revolving or fixed light, has proved superior to the highest powers of gas and oil.

The next division of the report has reference to the cost of installation and maintenance of the respective illuminants in a lighthouse. Collating the figures given, which at first sight are somewhat confusing, we may deduce the following comparison:—

——	First Cost.		Annual Maintenance.	
Electric station, without superposed lights.....		£17,749		£1,927
Gas station, quadriform as at Galley Head		20,516		1,687
Oil Station—				
Single light as at Anvil Point	£8,064		£724	
Add for change to triform	3,500		400	
	——	11,564	——	1,124

According to these figures oil is much the cheapest illuminant both as respects first cost and annual maintenance. A single electric light costs less for installation than a quadriform gas light, but is more expensive to maintain. It should be mentioned that in the totals for annual maintenance are included items for interest on original outlay at 4 per cent., and percentages for repairs and renewals of buildings, apparatus, and machinery. The actual expenditure for annual maintenance of each system is therefore considerably less than the totals given above.

Following the section dealing with the subject of cost, the Committee make some general references to a few points of collateral importance in connection with the general question of the relative merits of the respective lighting systems—the adaptability of the respective illuminants for showing coloured sectors of light to mark special dangers; the advantage of the lengthened flash of a broad flame in the revolving beam; the possible value of "atmospheric thrills," sky flashing, occultations, &c.; and the suitability of the lights for producing such effects.

Before stating their general conclusions upon the whole question, the Committee distribute a shower of acknowledgments to the various gentlemen by whose advice and assistance the experiments have been carried on, and make the following somewhat significant references:—

"Your committee have not considered it within their province to take any note of those questions of patent right or of the claims of inventors which have been raised in the earlier stages of the discussion which preceded their inquiry. They have endeavoured to give every facility to Mr. Wigham towards exhibiting his best effects in gas lighting within such limits as they deem compatible with safety and certainty in lighthouse service. Likewise, as respects the claims of oil, they have allowed full liberty to Sir James Douglass and their own staff. But throughout they have endeavoured to put aside all consideration of personal merit or credit, and to keep in view only the efficiency of lighthouse apparatus and its practical utility to the mariner."

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The Committee also think it a matter of congratulation that, although from antecedent circumstances some occasion of dispute might have arisen, the desire to act with thorough impartiality has, they believe, been recognised on all sides, and the whole investigation has been carried out without any breach of harmony among the parties concerned.

After weighing carefully the evidence given by photometrists and eye observers, and taking into account the questions of effectiveness, economy, and convenience as affecting each lighting system, the Committee thus sum up their opinion with regard to the relative merits of electricity, gas, and oil as lighthouse illuminants:—

"1. That the electric light as exhibited in the A experimental tower at South Forcland has proved to be the most powerful light under all conditions of weather, and to have the greatest penetrative power in fog.

"2. That for all practical purposes the gas light as exemplified by Mr. Wigham's multiform system in B experimental tower, and the oil light as exemplified by the Trinity House Douglass six-wick burners in multiform arrangement up to triform in C experimental tower, when shown through revolving lenses are equal light for light in all conditions of weather; but that quadriform gas is a little better than triform oil.

"3. That when shown through fixed lenses as arranged in the experimental towers, the superiority of the superposed gas light is unquestionable. The larger diameter of the gas flames, and the lights being much nearer to each other in the gas lantern, give the beam a more compact and intense appearance than that issuing from the more widely separated oil burners.

"4. That for lighthouse illumination with gas the Douglass patent gas-burners are much more efficient and economical than the Wigham gas-burners.

"5. That for the ordinary necessities of lighthouse illumination mineral oil is the most suitable and economical illuminant, and that for salient headlands, important landfalls, and places where a very powerful light is required, electricity offers the greatest advantages."

Part II. of the report, which will consist chiefly of diagrams, drawings, detailed reports on the electric lights and photometry, tabular matter, &c., it is expected will be published in a few weeks' time.

THE INDIAN TELEGRAPH SERVICE.

The following letter appeared in a recent issue of *The Times*:—

The grievances of the officers of the Indian Telegraph Service form a subject which may interest few of your readers, and it is not a time to ask for further outlay, however small, when we suddenly awake to the fact that the proximity of the Cossacks to the north-west frontier of our Indian Empire necessitates an additional annual expenditure of two millions for the increase to our Indian army alone. However, the grievances are real, and, as the numerous memorials submitted by these officers to the Viceroy and to the Secretary of State for India, at first collectively, and since the prohibition of joint memorials individually, have produced no substantial redress, I make no further apology for asking you to use the influence of your journal in bringing the matter before the public and the authorities of the India Office.

It does not follow because a memorial is addressed to a Viceroy or to a Cabinet Minister that it should ever reach the fountain head. A too obsequious henchman stands over on the alert to intercept the cry of him that hath no helper, and, as is popularly believed, burns the offending memorial before it has progressed its own length down the official labyrinth. Such, at any rate, appears to have been the fate of many memorials of the telegraph engineers, for although several were submitted to the Secretary of State upwards of eight months ago no reply has been received by any of the memorialists. In fact, I am informed on good authority that neither the Viceroy nor his Council has so much as seen these appeals for help. The memorials were strongly supported by the Director-General of Telegraphs, and an admirable scheme of reorganisation was submitted by that officer. This scheme, with the several memorials, was pigeon-holed by the Government of India, pending a reply from the Secretary of State regarding certain proposals submitted last year for the amelioration of the grievances of the Public Works Department. Finding that these proposals were to be rejected, the Government ordered the Director-General to withdraw his scheme, and to send in its stead one drafted by themselves, which is totally inadequate and calculated to satisfy no one. This scheme has now been forwarded to the India Office for sanction, so that, unless some steps are taken at once to prevent its being accepted, a cruel injustice will be done to one of the most deserving bodies of officers that have ever served the Government. It is for this reason that we ask you to bring their case before the public with a view to having it mentioned in the House. I am sending with this a carefully compiled statement showing the position and prospects (if such they can be called) of these telegraph engineers, with a summary of their grievances; but as this statement would occupy too much of your space, it will be as well to mention briefly the state of the Telegraph Department when these officers were appointed and the prospects that were held out to them.

In 1857 the Telegraph Department was in its infancy, and, with a view to introduce the Morse system of signalling, Sir William O'Shaughnessy, then at the head of the department, was deputed to England to train and send to India a certain number of officers qualified to teach Morse signalling. In 1857-58 no less than 71 officers, whose ages varied from 15 to 21 years, were drafted into the service, the department was reorganised, and the new appointments were apportioned between the Morse assistants and the officers previously appointed, "without injustice to the latter." The department worked satisfactorily for a time, but in 1865 complaints became so numerous that the attention of the Government was seriously drawn to the necessity for a wholesale reorganisation, and Colonel Robinson, R.E., the director-general, was addressed accordingly.

In his reply Colonel Robinson stated that he must have in the superior branch "none but gentlemen by education and feeling," and he desired that appointments might be given after competition and a technical course of study to "the sons of officers who had done good service to their country." He likewise asked sanction for 107 new appointments, to consist of nineteen superintendentships and eighty-eight assistant superintendentships. The proportion of higher appointments among a number of young men of nearly the same age was fixed far too low. The scheme was generally approved by the Secretary of State, and the India Office issued a memorandum detailing the tests to be passed, and pointing out the advantages of the "reorganised" service with its attractive appointments rising to £3,600 per annum. In this memorandum it was expressly stated that promotion to the higher grades would be "not by seniority but by merit." The salaries of assistant superintendents were to increase by annual increments of £25 from £240 to £500, but in a footnote it was added "these periods may be prolonged or shortened in special cases."

In the interval which elapsed between sanction and execution of the project, the first 92 of the 107 new appointments, which the India Office was holding out in London as inducements to the nomination assistants to enter the service, were filled up in India by the Indian Government from the Morse sssistants and inspectors appointed under the old system. The average age of the Morse assistants at the time of appointment was 19. The appointments by nomination were offered to men whose ages were above 18 and under 24 years. The selected candidates, many of whom had been within a few marks of passing for the Indian Civil Service, were required to pass a stiff examination in technical subjects, including physical sciences and mathematics, after a training of nine months, after which they had to obtain certificates from a qualified telegraph engineer after a course of four months' training in practical telegraphy. No less than 72 selected candidates were thus sent out to India to find themselves placed at the bottom of a fully officered department in which the first 92 appointments had already been filled by men of almost their own age, and in which most of them have now served for many years as supernumeraries. In 1872 the Government of India awoke to the true state of things, and no further appointments (excepting the appointment of two officers from the Indo-European Telegraph service) were made until 1878, when the first batch of officers joined the department through Cooper's-hill College. Of the working of the new scheme the Director-General, Colonel Robinson, wrote to Government:—

"This scheme, which met with the hearty approval of the Right Hon. the Secretary of State and the Government of India, has now been in operation four years, and its results have amply fulfilled the expectations formed of it. It has worked admirably; we have now as fine a set of young officers as are to be found in any service in the world; and in proof of its success I may mention that the higher officers of the English Postal Telegraphs think so well of it that they purpose to adopt the same system for filling their own ranks."

This is, indeed, high praise, and it will scarcely be believed that the officer who spoke so highly of the success of his scheme would, when he realised the hopeless position of his own "children," as pointed out in a joint memorial submitted in 1874, have refused to raise a finger to help them. Such, however, was the case. The present position of these fine young officers has been correctly summarised thus:—

(*a*) For 14 years after the organisation of 1865 no nomination assistant obtained any permanent promotion whatsoever.

(*b*) Now, after 19 years from the same date, only 14 out of the 72 are holding appointments in the two lowest grades of superintendents.

(*c*) The advancement of these 14 is the result of five years' working of a partial third reorganisation (1880) creating 16 new appointments with slightly increased salaries from the 1st of April, 1880.

(*d*) Lastly, 32 out of the 72 are still unpromoted, while the names of 26 have disappeared from the return to swell the list of casualties.

These 72 officers were the Secretary of State's "special nominees," who received nominations as possessing "decided claims upon the State for consideration." The special consideration that after all these years has been accorded to them is their present position of poverty and neglect, accentuated by a knowledge of the significant fact that the names of two have been added to the list of casualties for every one that has received a step in promotion. Such treatment compares most unfavourably with that meted out to "Morse assistants" appointed in 1857. A careful consideration of the average yearly casualties, compared with the numbers of the men who are still assistants, shows that the survivors of the last two batches of nomination assistants (1870-71) cannot hope to reach the lowest grade of superintendents until they have completed, at the very least, from 21 to 25 years' service. Such an outlook, in a service of such exposure as the telegraph, is nothing less than heart-breaking, and is without a parallel in any Home or Indian Department. The risks of the service and the exposure it entails are considered so great that the leading insurance companies will accept insurances on the lives of telegraph officers only at military rates. The work of the department has increased enormously of late years. All the important sub-divisions now are from 700 miles to 800 miles in length, and include, besides the up-keep of thousands of miles of wires, a technical charge of from 20 to 80 officers. The responsibilities of an officer in charge of a large sub-division are second to those of no executive officer in the country. Large sums of money pass through his hands. He has generally two or three construction works going on at once, besides technical supervision of innumerable offices, training classes, telephone systems, &c., and he has to make electrical tests of all systems of lightning conductors attached to Government buildings within his district. He must be ubiquitous, and turn up dressed like a gentleman at a moment's notice in any part of a district as large as Scotland. His clerical staff, if he is fortunate enough to have one, is

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totally inadequate for the preparation of his innumerable returns and for his ordinary office work.

The telegraph officer is liable to service in any part of India, Assam, or Burmah, and in time of war he has the entire charge of all field telegraph operations. He has to travel at all seasons of the year and in all climates. Many officers have spent the hottest months under canvas. Is it to be wondered at, then, that the casualities have been so numerous? What has been the average pay of this officer, from whom so much is required, for the first ten years of his service? Three hundred and twenty-one rupees a month. Scarcely a subsistence allowance in many parts of India. Five hundred rupees is the most that many of these gentlemen can ever hope to draw. Pensions are calculated upon the average emoluments, so that an officer not only finds it impossible to save money during his service, but on retirement he is obliged to eke out his miserable pittance with any work he can obtain. I know the case of one of these officers who is at the present time serving as a shop assistant in one of our large towns. Contrast his case with that of his more fortunate schoolfellow in the Civil Service, who on completing 21 years' service can retire on £1,000 per annum, and no further argument will be needed to show that there is at least one body of officers in the service of the Indian Government that has served its country loyally, but which in return has met with the most cruel injustice. These officers have memorialised till they are sick of the very name of a memorial; their cause has been warmly taken up by the press in India; they now appeal to the press in England to insist that at this the eleventh hour justice should be done to such of them as have survived the burden and heat of the day.

The actual profits of the telegraph department as recorded in the administration reports for the last seven years, exclusive of compound interest, have amounted to 52½ lakhs of rupees. The combined office scheme (postal and telegraph) lately introduced is already paying 16 per cent. It is, therefore, not too much to expect that the Government of India should expend a portion of these profits in affording relief to those officers who have done so much to bring the service to its present state of efficiency. Of the universal excellence of the work of the department, the Indian Press has but one opinion. The *Civil and Military Gazette*, March 16, 1885, writes:

"Of the importance of the work of the department and of the excellent work done by it there can be no two opinions. Whether in ordinary times, or in times of war or famine, it has always been found that the officers of the telegraph department have done speedily and thoroughly everything that was required of them. It is only fair that something should be given to a service of which so much is required; and we would, therefore, earnestly invite the attention of the Government of India to the present unsatisfactory state of things in the telegraph department." And, again, "No one can doubt that if the department possessed one tithe of the influence or power of organisation which is inherent in a body like the Civil Service, for instance, it would secure a hearing for its case and a remedy for its wrongs. The very fact that it is, so to say, nobody's child, should induce the Government of India and the Secretary of State to look closely to its interests. So far, however, is this from being the case, that telegraph officers cannot even get replies to the memorials which they have submitted regarding their position and prospects."

LEGAL.

Liardet and another v. The Hammond Electric Light and Power Supply Company (Limited).

The plaintiffs in this action were Messrs. John Evelyn Liardet and Thomas Donnithorne, and they sued the defendants for £45,000 damages for breach of certain covenants in an agreement under seal of June 17, 1882, and specific performance of the remainder of the agreement. By that agreement the plaintiffs contracted to sell to the company three patents—namely, (1) a patent of November 29, 1884, for hydraulic motors applicable for the production of electric light; (2) a patent of December 10, 1884, for an arrangement of electric lighting apparatus in railway trains; and (3) a patent of January 9, 1884, for an apparatus for storage of electricity. The price was to be £30,000 in cash and £15,000 in fully paid shares, £6,000 being paid in cash as a deposit on the signing of the agreement, and the completion of the contract was expressly made subject to the following conditions: 1. "The vendors shall prove that the accumulators made under the accumulator patent are, as against the Faure accumulator, practically half the weight and half the cost for equal power, and further, that they are equal for commercial and practical purposes to the Sellon and Volckmar system. 2. The said proofs shall be given on or before the 1st of December next. Immediately on failure of such proof the said deposit shall be immediately repaid to the Hammond Company." The plaintiffs alleged that they had performed their part of the contract, but charged the defendants with a refusal to complete. The defendants' case was that the plaintiffs had failed to give the proofs required by the contract, and that the experiments which had been made had fulfilled none of the conditions of the contract, and they claimed a return of the deposit without any deduction for the expenses of the experiments which had been made and the scientific opinions which had been taken.

His Lordship, after hearing the evidence of Mr. Donnithorne, the only witness called on behalf of the plaintiffs, held that the proofs which were stipulated for had never, in fact, been given, and that it, indeed, appeared that without the use of another patent, the Sellon-Volckmar, which had been denied by the patentees to the plaintiffs, it was not possible to give them. That being so, the action must be dismissed with costs, the plaintiffs must procure the return to the company of the whole of the deposit, and the company must take all necessary steps to enable the registration of the agreement to be cancelled at the Patent Office.

Charge of Perjury.

On the 26th inst., at the Marlborough-street Police-court, Chas. Dickson Aria, of 139, New Bond-street, appeared to an adjourned summons, taken out by Sir Coutts Lindsay, charging him with having committed wilful and corrupt perjury in an affidavit made by him on oath in a suit in the Chancery Division between Sir Coutts Lindsay and Co. and Smethurst and Co. Mr. George Lewis, solicitor, appeared for the complainant; and Mr. Gill, barrister, defended. From the evidence previously taken it appeared that the complainant, who is the proprietor of the Grosvenor Gallery, New Bond-street, some time since formed a company, under the title of Sir Coutts Lindsay and Co., for the purpose of lighting up that establishment by electricity, and in February last the company commenced to run an engine in connection with the works, and also erected a chimney at some distance from the premises occupied by the defendant, who is a lamp and oil merchant, carrying on business in the neighbourhood. In the month of June the defendant commenced an action against Sir Coutts Lindsay, to restrain him from having the chimney in the position it then occupied, and also from making a noise with the engine. Affidavits were filed on both sides, Sir Coutts Lindsay stating in his that the engine complained of was only a temporary one, and that the permanent machinery would be situated in a cellar 23ft. below the level of the street. The defendant thereupon filed a further affidavit, in which he swore that his premises extended to a depth of 25ft., and that the permanent machinery would probably cause more damage to his premises than that already erected. It was subsequently discovered that the defendant's premises were not of the depth stated by him, and Mr. Aria himself then filed an affidavit giving their correct dimension. On the case coming on for hearing, Mr. Lewis, after some discussion, said that his clients would be content that the summons should stand adjourned until the decision of the superior court had been given.—Mr. Gill urged that it would be unfair to the defendant to keep such a charge hanging over his head, and asked that the summons should be dismissed.—Mr. Newton said he considered the suggestion a fair and proper one, and should therefore adjourn the case until 26th January, 1886.

Change of Address.—Mr. Armand Levy (late of 252, Goswell-road), has removed to more central premises, 20, Chiswell-street, London, E.C.

Personal.—We learn that Mr. H. E. Harrison, B.Sc., A.M.I.C.E., has severed his connection with the Electrical Engineering College, Red Lion-square, of which he has been Principal since its foundation, and has entered into partnership with Mr. F. C. Phillips, electrical engineer, of 2, Victoria-mansions, Westminster.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Aug. 26.		Business Done Week Ending Aug. 26. Highest.		Lowest.	
Anglo-American	29½,	30½	.....	30	.....	28½
Do. Preferred	50½,	51½	.....	51½	.....	50½
Do. Deferred	8,	9	.....	8½	.....	8½
Brazilian Submarine	11,	11½	.....	11½	.....	11
Cuba	12,	12½	.....	12⅞	.....	12 1-16
Do. Preference	18,	19	.....	—	.....	—
Direct Spanish	1½,	2	.....	—	.....	—
Do. Preference	12,	12½	.....	—	.....	—
Direct United States Cable	8¾,	9½	.....	9 1-16	.....	8 13-16
Eastern Telegraph	11⅜,	11⅝	.....	11 13-16	.....	11 7-16
Do. 6 per Cent. Preference	13,	13½	.....	13⅝	.....	13½
Do. 5 per Cent. Debentures, 1899	105,	108	.....	—	.....	—
Eastern Extension	12⅜,	12⅞	.....	13 1-16	.....	12⅝
German Union	9½,	9⅝	.....	9½	.....	9⅝
Globe Telegraph and Trust	6⅞,	7⅛	.....	7⅛	.....	6⅞
Do. Preference	12¾,	13	.....	13	.....	12 13-16
Great Northern	13½,	14½	.....	14 7-16	.....	—
Indo-European	30½,	31½	.....	31⅜	.....	30½
Reuter's	7⅛,	8	.....	8	.....	7⅞
Submarine	180	190	.....	—	.....	—
West India and Panama	⅜,	1	.....	⅜	.....	—
Do. 1st Preference	8½,	8⅝	.....	8½	.....	8½
Western Brazilian	6½,	6⅝	.....	—	.....	—
Western Union 7 per Cent. 1st Mortgage	120,	124	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	103,	105	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅛,	⅜	.....	11-16	.....	⅛
Oriental	⅛,	⅜	.....	—	.....	—
United Telephone	11,	11½	.....	11 5-16	.....	11½

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	.....	—	.....	—
Do. (fully paid)	2½,	3½	.....	—	.....	—
Hammond Light (£3 15s. paid)	1-16	3-16	.....	—	.....	—
Swan	⅛,	⅜	.....	⅛	.....	—
Maxim-Weston	⅛,	⅛	.....	⅛	.....	—

MISCELLANEOUS.

Telegraph Construction	87,	88	.....	87½	.....	—
India Rubber, Gutta Percha, and Telegraph Works	23½,	24½	.....	—	.....	—

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NOTES.

NOTICE OF REPAIR.—The cable between Fao and Bushire is now repaired.

ELECTRIC RAILWAY WANTED.—The Board of Management of the new American Exhibition to be opened this winter at New Orleans has invited tenders for an electric railroad in the grounds.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of August, 1885, were £1,276, against £1,190 in the corresponding period of last year.

IN AN OVEN.—An Edison incandescent light is used with great success in a baker's oven at a restaurant in Chicago. Why not? The incandescent light burns merrily enough inside our English Law Courts.

NEW COMPANY.—Articles of incorporation have been filed for the Buel Electric and Pneumatic Company, of New York, which is organised to push inventions relating to the application of electricity and compressed air to heating and propulsion.

STRUCK BY LIGHTNING.—At Harmarsville, Pa., recently, a boy, twelve years old, who was learning to telegraph, and who had his hand on the key, was struck by lightning and instantly killed. The operator in charge of the office was also stunned by the electric discharge.

ARC LIGHTING.—We give it upon the authority of Mr. Leggett, of Detroit, that at a distance of 1,000 feet the light from two groups of four 2,000 candle-power arc lights placed 150 feet from the ground was equal to that of a 16 candle-power gaslight at a distance of 45 feet.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the weeks ending Aug. 7 and 14 amounted to £2,648 and £3,397 respectively; and for the weeks ending August 21st and 28th they amounted to £2,778 and £3,073 respectively.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 31st August are £2,293, as compared with £2,527 in the corresponding period of 1884. The May receipts, estimated at £7,624, realised £7,641.

UNDERGROUND WIRES IN BROOKLYN, U.S.A.—The Commission on putting electric wires underground in Brooklyn met August 11th to consider plans. The Fire Commissioner asks the wire Commission to grant a permit to the Fire Department to extend its overhead telegraph system.

CONSOLIDATION OF AMERICAN COMPANIES.—The consolidation of the Brush, Weston, and the Merchants' electric light companies, of Boston, Mass., has been completed. The new company has 700,000 shares, of which the Brush interest obtains 250,000 and the Weston and Merchants 225,000 each.

LEGAL.—In the Chancery Court on Tuesday last, before Mr. Justice A. L. Smith, a petition was presented by F. Horner Lyell, a creditor and shareholder in the Electro-Amalgamator Company, for a winding-up order. No counsel appeared when the case was called, and the judge directed that it should be struck out.

CHEAP TELEGRAMS IN AUSTRALIA.—The reduction of the fee from 2s. to 1s. for the transmission of ten-word telegrams from Victoria to New South Wales has resulted in an increase of 17,617 in the number of messages, or 30 per cent., but a falling off in the revenue of nearly 11 per cent. This result is considered satisfactory.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of August was 2,832, estimated to produce £2,200, against 2,916 messages, producing £2,515 in the corresponding month of last year. The traffic receipts for the month of May, estimated at £3,700, realised £3,736.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the weeks ended Aug. 7 and 14 were £1,913 and £1,919, and for the weeks ended 21st and 28th August £1,562 and £1,759, respectively, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company in each case.

THE CHAIR OF ENGINEERING IN EDINBURGH UNIVERSITY.—Professor George Frederick Armstrong, M.A., F.G.S., C.E., who filled the Chair of Engineering in M'Gill University, Montreal, and the Yorkshire College, Leeds, has been appointed to the Chair of Engineering in the University of Edinburgh, in room of the late Professor Fleeming Jenkin. The appointment was in the gift of the Crown.

INCREASED BUSINESS.—The business of the Consolidated Telephone Construction and Maintenance Company in magneto-bells and other instruments has increased so much of late that the directors of this company have deemed it advisable to order from America some further machinery adapted to their manufacture. The machinery having now arrived, a considerably increased output is expected.

ELECTRIC LIGHT AT LIEGE.—It is reported, on good authority, that a company, promoted by Mr. A. Mullender, U.S.A. Consul at Liége, has been formed in that city, with a capital of 275,000f. (£11,000), divided into 1,100 shares of 250f., or £10 each, nearly all subscribed, for working the patents of the Thomson-Houston International Electric Company. It is also said that the new company has sufficient orders for lighting to begin active operations in November.

THE COMING ELECTION AND THE POST OFFICE.—In view of the forthcoming General Election, the Postmaster-General has issued a warning to officers of the Post Office against taking any prominent part on one side or the other in the political contest. This intimation is addressed especially to the case of postmasters; but as the officers of the Post Office are specified in general terms as Public Servants, we imagine that those belonging to the Postal Telegraph Service are included in the prohibition.

THE SCOTTISH TELEGRAPH CLERKS.—The Edinburgh telegraph clerks have received a reply to their memorial of 10th July, in which payment for Sunday labour was asked. Lord John Manners, in stating his inability to concede payment for the work performed, says similar applications have been very carefully considered by his predecessors, and that a decision was arrived at which was communicated to the memorialists within the last few months. He regrets that, on a review of the circumstances, he can see no sufficient reason to depart from that decision.

THE BECHUANALAND TELEGRAPHS.—According to Sir Charles Warren's report, the telegraph service from Shoshong to Taungs can be maintained for £3,000 per annum. This sum would pay for about ten policemen, and there can be no doubt that a telegraph line over 400 miles in length would be of more advantage than these men, especially as the linesmen themselves are in the nature of police. When the expedition

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arrived in Bechuanaland there were employed about twenty policemen on the road from Vryburg to Barkly carrying despatches, at a cost of £6,000 per annum.

A DEFECTIVE FIRE ALARM.—As we are going to press we notice that, in connection with a fire which occurred yesterday at the Industrial Home for Boys in Islington, a fire alarm in the vicinity proved to be out of order. It would be interesting to know if the fire alarm circuits are regularly tested and their condition ascertained. It is absurd to suppose that they can keep themselves in good working order. Someone ought to be held responsible if, as is stated, the failure of the alarm led to excessive delay in procuring aid, and not improbably the total destruction of the building.

THE ACOUSTICS OF THUNDER.—Among the papers read at the 120th corporate meeting of the Boston Scientific Society was one by Mr. H. P. Curtis on "Acoustics of Thunder." He said that "contrary to the assertions of physical treatises, which hold that thunder is audible only 10 to 15 miles or possibly 18 miles from the generating flash, as the result of 10 years' observation in Europe and here, he had heard thunder at a distance of 100 miles from the flash. Other observers had noticed flashes, and by timing the interval between flash and thunder, a distance of 150 miles was obtained."

COST OF TELEPHONE SUBSCRIPTIONS.—London, £20; Paris, £24; Riga and Odessa, £25; Austria, £9 to £15; Germany, from £10, with an increase of £2. 2s. for every 1·24 mile over two; Italy, varying from £4. 12s. to £7 with the towns; Norway, £4 to £8, according to distance; Sweden, £6. 8s. to £10. 16s.; Holland, £10; Portugal, £15 for traders and £7 for private individuals; Switzerland, £4 to £10; New York, £40 a year; Boston, Chicago, Philadelphia, Baltimore, St. Louis, £30. Cities of an average of 60,000 to 100,000 population £30 a year. Little towns with 50 or 60 subscribers £10 a year.

THE LIGHTING OF DUNDALK.—There seems to have been some division of opinion in Dundalk as to the lighting of the town. Some time ago tenders or proposals were invited with a view to selecting electricity as the illuminant, and finally a contract was, we are informed, entered into with a Belfast firm to put down an installation. Delays, however, arose, and it transpired that an application for a licence would have to be made to the Board of trade, and ultimately, O, degenerate Dundalk! oil lighting was adopted. The inhabitants of that town are we believe very justly incensed at the turn matters have taken.

IRON TELEGRAPH POLES.—Iron telegraph posts have been introduced with great success in Switzerland, and are now being extended daily. They have been already put up on Swiss railways a distance of 350 miles. In Prussia they are being placed experimentally on the railway from Weissenfels to Gera, and on the line between Berlin and Potsdam. As iron is now so cheap, it is considered that in a short time they will altogether replace the old wooden poles in Germany, which cause frequent interruptions to telegraphic communication from rotting or being blown down by every high wind, especially in exposed situations.

THE POST OFFICE VOLUNTEERS IN EGYPT AND THE SOUDAN.—The Postmaster-General notifies that he has seen with great pleasure that in his report to the Secretary of State for War upon the recent operations on the Upper Nile and near Suakin, dated Cairo, 15th June, 1885, General Lord Wolseley, G.C.B., commanding Her Majesty's Forces in Egypt, makes the following remarks, which he publishes for general information:—"The volunteers were represented by men of the Volunteer Engineers and of the Post Office Corps, who, both by their zeal and their soldier-like bearing, sustained the reputation of the service to which they belong."

TRANSMISSION OF POWER IN NEW ZEALAND.—It is reported from New Zealand that a Dunedin electrical engineering firm is carrying out a contract for the transmission of power to run a stamping battery of twenty heads. The scene of operations is a gold mine in the mountainous country some thirty miles behind Lake Wakatipu, and the power to run the battery is transmitted from a waterfall in the neighbouring valley, straight over a mountain of about 2,000ft. in height, and for a distance of about two miles. The conducting wire is of the same size as an ordinary telegraph wire, but of copper, and is suspended from telegraph insulators in the usual manner.

LAUNCH.—Messrs. Wigham, Richardson and Co., of Newcastle-on-Tyne, launched on Saturday last the screw s.s. "Buccaneer." She will be fitted up for cable work, and will be used in company with the India Rubber, Gutta Percha, and Telegraph Works Company's s.s. "Silvertown" in the laying of the West Coast of Africa cables. She will be off the works of that company about the end of this month. Her speed is expected to be from 13 to 14 knots. The same company are at present shipping 530 knots of heavy cable on board the s.s. "International" and s.s. "Dacia," which is to be laid in the Peruvian Gulf, under the superintendence, we understand, of Colonel Bateman-Champain.

THE TELEGRAPH IN SOUTH AMERICA.—Later reports from America announce that the American Telegraph Company has opened telegraphic communication between Chillan, Talcahuano, Concepcion, Coronel and Lota, and it is expected that the line in course of construction between Chillan and Talca will be completed by the end of the present month, which will place the port of Valparaiso in direct communication with the southern part of the republic. A telegraph line is to be erected between Arica, in Peru, and Lapaz, the capital of Bolivia, the tariff to be two Bolivian pesos per word. The line is to be completed within six months. The Peruvian telegraph line is now in operation to Casma.

THE EARTHQUAKES.—A telegram from Vienna reports that on Wednesday afternoon there were repeated and severe shocks of earthquake, lasting for three seconds, at Kindberg, in the Styrian Alps. The inhabitants fled from their houses, which have in many instances been damaged, though not very seriously. In this part of Austria earthquakes have been of frequent occurrence in recent times. A telegram from the Canary Islands also states that a shock of earthquake has been felt there. No damage is reported. A shock of earthquake has been felt in Melbourne. In some places it was very severe. It was accompanied by a rumbling noise like that made by a train. No shock so severe had been felt for many years.

A CONDITION OF ELECTRICAL CONDUCTIVITY.—A paper was recently read before the Paris Academy of Sciences on the electric conductibility of solid mercury and of pure metals at low temperatures, by MM. Cailletet and Bouty. From numerous experiments made with mercury, silver, tin, aluminum, magnesium, copper, iron, and platina, the authors conclude that the electric resistance of most pure metals decreases regularly when the temperature is lowered from 0 deg. to 123 deg., and that the coefficient of variation is apparently much the same for all. It seems probable that the resistance would become extremely slight at temperatures lower than 200 deg., although this point has not yet been practically tested.

THE MINING EXHIBITION IN GLASGOW.—The arrangements in connection with the forthcoming mining exhibition,

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to be held in Burnbank Drill Hall, Glasgow, this month, under the auspices of the Mining Institute of Scotland, are now in a forward state of completion. The whole place, grounds, and halls will be illuminated by electric lights, and visitors will have an opportunity of studying how the light is produced and maintained, and they must not forget, says a Scottish contemporary, that they are looking at what is almost sure to be the mine-light of the future. The example set by Mr. Watson, of Earnock, is not likely to be long without a following, and every further effort will be a step nearer perfection in mine lighting.

UNFORTUNATE.—At the Sunderland Bankruptcy Court on the 27th ult., Wm. Edwin Irish, electrical engineer, and the inventor of several electrical appliances of great merit, came up for first examination. He had acted as manager of the United Telephone Company for the North of England, and of the Northern District Telephone Company. He commenced business in 1881 with a capital of £500. His liabilities were £3,300, which included a liability of £2,300 to the Northern District Telephone Company, who had obtained a judgment against him for £1,700. His assets, he thought, would be about £6,000, including seven patents for electrical inventions, which he valued at £5,000. The cause of his insolvency was litigation with the Northern Telephone Company. The further examination was adjourned until 8th October.

LIGHTING A TUNNEL.—According to an American contemporary, Manager Locke continues to work on the problem of lighting the Hoosac Tunnel. He is of the opinion that some sort of an engine will ultimately be used in the tunnel which will not make any smoke, and that when this is done the tunnel can be lighted with electric lights. When this is accomplished it will become popular for excursionists, who will pass through, stopping at the central shaft, where they can climb up the stairway through the galleries to the base of the shaft and take a look to the top of the mountain, over 1,000ft. above. It is proposed to build a platform out into the shaft and have it so arranged that the people who visit this unpoetic spot can take in the stupendous height without being drenched by the constantly falling water.

A DEGENERATING DYNAMO.—All our efforts on behalf of electricity, if we are to credit the *Glasgow Herald's* rendering of a par from *Engineering*, are unfortunately not on the side of progress. Our contemporary says :—"We may also mention that four large punkahs are now driven at the well-known Restaurant Marguery, Boulevard Bonne-Nouvelle, Paris. They are placed upon the terrace of the Gymnase Theatre, which M. Marguery has rented for the summer season, and actuated by the Gramme motor fed by the current from a *degenerating dynamo* already used on the premises for domestic purposes." We may inform our readers that in substance this is an old note of ours, which appears to have been reproduced by *Engineering* and then degenerated by our Scottish contemporary, whose joke was of course unconscious.

GALLANT ACT OF A TELEGRAPHIST.—A brave act was performed at Dover on Saturday evening by a telegraph clerk, named James M'Cadden, engaged at the Dover General Post Office. M'Cadden, who is only 18 years old, was engaged at the telegraph room which overlooks the docks, when he noticed a man belonging to the Royal Irish Militia, who was the worse for liquor, and in the company of two comrades, stagger and fall in the dock. M'Cadden at once left his bench, and running out on the quay, dived into the water and succeeded in bringing the drowning man to the surface. The occurrence was witnessed by a large number of people, who expressed their admiration for the young man's bravery. M'Cadden had great difficulty in supporting the man, as he was intoxicated; but notwithstanding this he afterwards swam to and assisted in saving another soldier, who had jumped in after his comrade, but could not swim.

THE "HELIOGRAPH."—*Apropos* of Sir Henry Mance's recent honours, the following may be of interest :—The "heliograph," called also heliotrope, an instrument much used of late for signalling messages by sun flashes reflected from mirrors, between the sections of an army in the field, was invented by Karl Freidrich Gauss, one of the best mathematicians of modern times. He was born at Brunswick on the 30th April, 1777, and early displayed such remarkable capacity for mathematical calculation that (his parents being poor) the Duke of Brunswick took charge of his education. From the age of eighteen he gave many proofs of his extraordinary mental power, and in 1821 he was charged by the Hanoverian Government with the triangulation of the kingdom of Hanover. In executing this work Gauss found that the appliances then in use did not allow the vertices of the triangles to be seen distinctly from a distance, and to remedy this defect he invented the heliograph, which under recent improvements has been made serviceable for distances of nearly 200 miles.

SOLID ELECTROLYTES.—The following letter has been written to *Nature* by Prof. Silvanus P. Thompson :—"Having been for some months occupied with the electrical behaviour of the compounds of copper, silver, and lead with tellurium, selenium, and sulphur, I can confirm the observation communicated to your pages by Mr. Bidwell as to the behaviour of sulphide of copper. He has constructed a primary cell with solid sulphides for the electrolytes. The smallness of the electromotive force which he has obtained is entirely due to the close proximity of copper and silver in the thermo-chemical series in respect to their heats of combination with sulphur. The theoretical electromotive force should be only ·05 volt. Let me add to Mr. Bidwell's observation one of my own. If a piece of sulphide of copper is placed between platinum electrodes, a current of electricity from a battery can be passed freely through it, as it is a good conductor. But if after a time the battery is removed and the platinum electrodes are connected with a galvanometer, a current is observed. The solid sulphide between two platinum plates constitutes, therefore, a secondary cell or accumulator capable of being charged and discharged."

THE NOTTINGHAM CENTRAL POST OFFICE.—The business of Nottingham has increased enormously of late years, so far as the post office is concerned, and the addition of other departments has greatly added to the congestion. The changes at present being made are of a most extensive character, and are necessitated by the adoption of a "dead letter" department and the introduction of sixpenny telegrams. Recently a story was added to the building, now a doorway is being opened out at the corner of Victoria and Queen-streets, giving a fresh entrance to the structure. The postmaster's (Mr. Pratt) and the chief clerk's (Mr. Richard) offices have been removed from the first to the second story, to make room for an extension of the accommodation of the Parcels Post department. The telegraph department, except for the mere receipt of messages, which will be as usual on the ground floor, has been removed bodily from the second to the third or recently added story. The entrance is still in Victoria-street. On the left are the rooms of the chiefs, and beyond are the instruments. The alterations are being carried out under the direction of Mr. Revel, of the Board of Works, by Messrs. Fish and Son, contractors, Nottingham.

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A DISPUTED POINT.—Mr. Calladon recently, addressing the French Academy of Sciences, said that there was no truth in the popular supposition that a building with a metal roof, or with metal in its construction, is more likely to be struck by lightning than a building composed wholly of non-conducting materials, providing there is no means of electric communication between the metal and the earth. A house in Neufchatel, Switzerland, had been struck by lightning and burned, and somebody suggested that a lot of old iron stored in the attic had attracted the electric fluid. It was this suggestion that brought Mr. Calladon to his feet. He said that the iron had had nothing to do with attracting the lightning, but had probably been a cause of the burning of the building after it had been struck. The explanation of that is that a combustible substance placed between two conducting surfaces (in this case the humid atmosphere and the pile of iron) is generally sure to take fire when an electric current is passed through it from one conducting surface to the other. The lightning having struck the house, concludes the scientist, found its way to the metal within and ignited whatever combustible material it passed.

THE TELEPHONE AND FIRES.—In connection with the fire which broke out in the extensive timber yard of Mr. T. Forman, 148, Kennington-road, on Saturday morning last, we learn that upon the news being communicated to Superintendent Hamlyn he immediately ordered out all the nearest engines, and sent by telephone a message to the authorities at Southwark stating that engines and men were turning out for Forman's timber yard in the Kennington-road, well alight, and asking that extra steamers and men from the three other districts on the north of the river should be immediately ordered to the scene. This serious message, when it was communicated to Mr. Simonds, the second officer of the brigade, at once produced the order for help to be sent on, and engines from Brompton, Chelsea, and Kensington in the "A" district, from Watling-street and Scotland-yard in the "B" district, and from Mile End and Shoreditch in the "C" district, were soon on their way to the fire. In the meantime the engines from Kennington, Tooley-street, Rotherhithe, Deptford, Old Kent-road, Camberwell, Brixton, Clapham, and Waterloo-road had begun to arrive in rapid succession; and as promptly as they appeared their powerful machinery was got to work, and water was pouring on the flames from half a dozen different directions within ten minutes of the first raising of the alarm.

TOWN LIGHTING BY ELECTRICITY.—The experience gained at Detroit is interesting, inasmuch as there was a keen competition between electricity, gas, and oil for the lighting of the city. For the current year the tender of the Electric Light Company is 89,300 dols., against 40,000 dols. of the gas and naphtha companies, a difference of 49,300 dols. in favour of the latter when cost alone is considered, though it is suggested that this tender assumes a loss of at least 40,000 dols., a loss which the gas companies agreed to in hopes of ousting their more successful rival. The main cost, however, came to be, as we always said it should, a secondary consideration. The citizens would not have gas or naphtha at any price, they cut down the lamp-posts, and finally the cry of "more and better light" prevailed. A year ago the electric tender was 95,000 dols. for lighting an area of 10·5 square miles. This area, as in almost all large towns, consists of a thickly populated centre, with a suburban and semi-suburban district. In order to light the area 90 skeleton iron towers were erected, three being 175ft. high, the remainder 150ft. high, placed in triangles 1,000 to 1,200ft. apart in the centre and 2,500 to 3,000ft. apart in the suburban districts. On these towers 358 (2,000 nominal candle-power) arc lights were placed, but these were supplemented by 23 pole lights in special positions. It is said that the lighting of the city was extremely good, streets, lanes, and alleys being lighted as by moonlight, to the great benefit of the inhabitants. Meanwhile we in the old world are content with the old order of things, because if we want more light we are unwilling to pay for it.

A MEAN THIEF.—At the Mansion House recently Edward Ratcliff was brought before Alderman Sir Andrew Lusk, M.P., charged with stealing a purse and money, the property of Her Majesty's Postmaster-General. The evidence showed that the prisoner was in the employment of an electric light company, and it was his duty to attend to the electric lights in the premises of the Post Office Savings Bank Department in Queen Victoria-street. Recently there had been several complaints made of the loss of purses belonging to young ladies employed in the department, and accordingly the Post Office authorities took steps with a view of finding out who the thief was. On Friday a purse containing marked money was placed in one of lockers in the young ladies' dressing room, and a Post Office constable took up a position in a cupboard where he could see anything that took place. He saw the prisoner come into the room and look into four lockers, but took nothing out. Afterwards, however, the prisoner looked into the fifth locker, which contained the purse and marked money. The prisoner took the purse out, and was walking away when the police officer stopped him and took him in charge for stealing the purse. It was said that the prisoner had no business in the room at all; but he asserted that he had to go there to look after the lights. The prisoner, in defence, denied that he had stolen the purse, and urged that he had gone into the room with the *bonâ fide* object of attending to the lights, as was his duty. He said he bore an excellent character, and was placing the purse back in the locker when the constable suddenly came out of the cupboard and accused him of stealing it. He emphatically denied the charge. Sir Andrew Lusk said it was a very ungallant thing for the prisoner to try to take away a poor girl's purse. He sentenced the prisoner to three months' imprisonment with hard labour.

AN INDESTRUCTIBLE EARTH CONNECTION.—Mr. Justin Malisz, after drawing attention to the defects of ordinary earth plates, describes his method of preparing an earth connection which conducts well, is self-depolarising, and has its junction with the line easily accessible. A hole about 6½ft. deep, and about 3ft. square, is dug in the ground, and a layer of coke laid on the bottom, and firmly stamped down. A tube with its lower end resting on the coke is placed against one face of the hole, and filled tightly with coke almost to the top. The hole is then filled up, and the earth rammed well round the tube, the upper part of which projects above the surface of the ground. A lump of coke or retort carbon, to which a copper band is rigidly attached by soldering or pouring molten lead over it, is put in the tube, and a final layer of coke pressed firmly around it. The copper band projects from the top of the tube, and to this band the line or the lightning conductor is soldered. By this arrangement a constant earth connection is obtained, as coke has a uniform conducting power under all circumstances, and its large surface ensures for the current an easy path to earth. The column of coke in the tube not only enables the junction between earth and line to be permanently above the ground and easy of access, but it has a depolarising action on the bottom layer of coke, thereby preventing the prejudicial effect of a counter electromotive force, which in so many cases renders an ordinary earth-plate useless. Mr. Malzis

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considers that the coke, which in the upper part of the tube is in contact with the air, condenses oxygen, and can likewise absorb and oxidise the hydrogen formed by the current. The gases resulting from polarisation rise through the column of coke in the tube, and are dissipated in the air, and this column in virtue of its power of condensation plays an important part in the deplorisation of this form of earth connection.

LARGE DYNAMOS.—There is rapidly approaching completion at Messrs. R. E. Crompton's works the construction of three huge dynamo machines, driven direct by high-speed engines. They are intended to form part of an electric light installation to be carried out by this firm for the Imperial Continental Gas Association at Vienna, the Emperor having, since the great fires that took place in that city some years ago, adopted electric lighting on a large scale. In order to facilitate the erection of these machines and engines, a shop has been specially built for their reception. Each engine and machine stands in a cast-iron bed plate 12ft. long, 4ft. 6in. wide, and weighing $2\frac{1}{3}$ tons. These machines stand 7ft. 6in. from the ground. The massive field magnets on each machine are of the finest wrought iron and weigh four tons. The armatures or revolving parts are $16\frac{1}{2}$in. in diameter, and 3ft. long, and are carried on spindles $5\frac{1}{8}$in. diameter in the centre. No less than $5\frac{1}{2}$ miles of copper wire have been used in their construction. Each machine will be driven direct by a Willans high-speed compound engine of latest type. Each dynamo is intended with ordinary running to give an output of 120 amperes current at a pressure of 600 volts, equal to nearly 100 horse-power—that is to say, these machines will be capable of supplying the power of about 3,600 16 candle-power incandescent lights, which in practice are to be supplied through accumulators. Messrs. Crompton have been entrusted with the contract for the boilers for the installation, and also the whole arrangement of the engine and machine rooms, which arrangements have been got out after careful consultation with the Vienna Company's engineer, M. Monier. When finished the installation will be one of the most important yet attempted, and will, it is hoped, be so successful in its results as to induce many local bodies and corporations to erect central lighting stations in this country.

A SUGGESTION.—"Railroad men," says the *St. Louis Globe Democrat*, "have recently been considering the feasibility of using the electric light as headlights to their engines, and for the purpose of generally illuminating trains. The difficulty in the way seems to be that the jar of the locomotives and coaches is liable to cause uncertainty in the continuity of the light. But there is one method that does not appear to have been discussed to which this objection will not apply. That is, utilising the existing telegraph poles and wires for the purpose of making a continuous illumination along the railroad tracks. There are thirty telegraph poles to the mile, and if on every other one of these were hung an electric lamp, the entire track could be made as light as day. This would do away entirely with the need of the expensive and cumbrous headlights, and, to some extent, with the necessity for using oil-lamps in the train. It would also obviate all the dangers to railroad traffic that are now incident to the darkness. Accidents resulting from washouts, or fallen trees, or landslides would be things of the past. Obstructions placed by malicious persons on the tracks would be seen at once, or, were the malefactors to take the precaution of cutting the wires before attempting to wreck the train, that would at once extinguish all the lights within the circuit, and give warning to the train officers that danger was ahead. Moreover, suppose the case of a train despatched on mistaken orders, as soon as the case was discovered, the operator at the battery could, by a simple movement of the hand, extinguish the lights, which would be a signal for the train within his circuit to come to a stand and wait for orders. It way be urged against the suggestion that some of the lamps might get out of order and remain so, unless a close and expensive system of supervision were maintained. This difficulty can be met by a further suggestion that, with a simple system of lettering and numbering the lamps, the engineers of passing trains could report to the next station what particular lamp or lamps might happen to be out of order. At any rate, the plan, which has been suggested by a practical railroad man of great experience, presents so many points of apparent advantage that it must be worth examination. To the public at large it would certainly give a greater feeling of security than is possible under the present system; and if the economical questions connected with it can be satisfactorily adjusted, it would undoubtedly be considered a great step in advance."

THE ELECTRIC LIGHT AND LIGHTHOUSES.—The shipping trade of the Firth of Forth has rapidly increased during recent years, and loud calls for more lights have been made, and these are being gradually supplied. St. Abb's Head, near the mouth of the Forth, was crowned with a ten second flashing light in 1862, and from the Island of Fidra, which lies nearly opposite North Berwick, a group-flashing white light (the first of its kind in Scotland), showing two flashes in quick succession, with intervals of about fifteen seconds between the groups, was exhibited for the first time on 15th April last. The Fidra light is shown from a tower at an elevation of upwards of a hundred feet above high water, and is visible about seventeen nautical miles. In order to guide vessels through the somewhat intricate navigation leading to Queensferry, Bo'ness, and Grangemouth, a tower has been placed on the Oxscares Rock, which lies to the east of Inchcolm, and in all likelihood the light will be shown from it before winter sets in, as the work is rapidly approaching completion. When all these lights have been exhibited, the sailor will have no cause of complaint so far as the chain of lights on the south side of the Firth is concerned. But the most powerful of all the lights will be that of the electric light on the Isle of May. Messrs. Stevenson, engineers to the Northern Lighthouse Board, prepared designs for the requisite additional buildings, and also for the optical and electrical apparatus for the installation of the new light, and a contract has already been entered into for the erections on the island, and some progress has been made with the buildings. Messrs. Stratton, the contractors, taking advantage of the good weather, have also landed on the island a large quantity of materials, and are vigorously pushing on the works. The optical apparatus for this light is of a novel description, on the condensing principle of Mr. Thomas Stevenson, and will show four flashes in quick succession every half minute, while a small arc of fixed white electric light will be shown in the direction of the North Carr Rock in supplement of the present low light. As indicative of the intensity of the proposed light, it will probably be nearly a thousand times stronger than the present powerful oil light. Provision has also been made for dipping the light during fogs, so as to increase the power at nearer distances to the lighthouse than the horizon. The increase in the power of the light is gained, not by adopting unusually powerful electric apparatus, but is due to the special optical apparatus which is to be employed. When the electric light has been established, the Isle of May lighthouse will have passed through all the changes in the art of lighthouse illumination, from the open coal fire to the latest development of optical and electrical apparatus.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 291.)

As regards other causes influencing the electric field in the space external to the conductors, there remains the problem (*a*) of the last section. If, in it, we put $e=0$, we reduce it to the common electrostatic problem :—Given the volume electrification within, and also the charges upon equipotential surfaces bounding the nonconducting region (at least when they require to be independently stated, apart from the volume electrification), show that the field of force is determinate. We might take this for granted, and confine our attention to impressed force only; but as it makes scarcely any difference to include electrification, we shall do so. We have then the conditions

$$\text{div.}c(e+\text{F})=4\pi\rho, \qquad \text{curl}\text{F}=0,$$

to be satisfied by F within the non-conducting region; and, at any bounding surface,

$$\Sigma\text{DN}=q, \qquad \text{VFN}=0;$$

the first of these expressing that the given charge q on the surface is the total normal displacement from it into the non-conductor, and the second that the force has no tangential component at the surface, or is normal thereto, or that the surface is equipotential.

Assuming F to satisfy the above, alter it to $\text{F}_1=\text{F}+f$ in any way that does not alter the electrification or the charges. That is, subject f to

$$\text{div.}cf=0, \qquad \Sigma\text{N}cf=0$$

within the region, and at a surface, respectively. We have merely to show that this change increases the electrostatic energy $\Sigma\text{F}c\text{F}/8\pi$, a quantity that must have a minimum, to show that F is determinate, by reasoning used before, which need not be repeated; and, since

$$\Sigma\text{F}_1c\text{F}_1=\Sigma\text{F}c\text{F}+\Sigma fcf+2\Sigma\text{F}cf$$

wherein the second sum on the right is positive, we have only to show that $\Sigma\text{F}cf$, the third sum, vanishes. Now, by the first condition for f, we have cf perfectly continuous within the region; and, by the second, as much enters as leaves any bounding surface. That is, cf is any closed flux whatever, either closed entirely within the region, or else partly or wholly through the rest of space. Therefore $cf=\text{curl}\text{Z}$, Z being any function whose curl is cf, and

$$\Sigma\text{F}cf=\Sigma\text{ZVNF}=0;$$

the first summation extending through the region, the second over the bounding surfaces, and vanishing because $\text{VNF}=0$ at every point thereof.

This finishes the question of the determinancy of F. In any conductor it is settled by the distribution of impressed force and of conductivity therein, and the interior displacement and electrification follow. Then, knowing the tangential force set up at the boundaries of the non-conductors due to impressed force in the conductors, this is sufficient to settle the force all through the non-conductors when the distribution of capacity is given, provided there be no electrification in them, or impressed force, or boundary charges. No electrification or charges will be produced, as the displacement in the non-conductors can be closed through the conductors. Should there be electrification, &c., in the non-conductors, these have no effect on the conductors, produce no boundary tangential force, and their effect in the non-conductors may with convenience be separately considered. Knowing F to be determinate through all space, we may construct a potential to suit it, fixing its value arbitrarily at any one point. Should we, however, make the potential the direct object of attention in our investigations, instead of the force, we should greatly complicate certain parts of them. For example, to show that e in the conductors fixes F in the non-conductors when there is no electrification, &c. If there are n conductors, n fields of force (namely in them) are found by the conductivity conditions. The potential is therefore known over the surface of all the conductors, except as regards a constant for each. If we assume these constants to be known, we may prove that the thus fixed boundary potential fixes the potential throughout all the non-conducting regions. But the resulting fields of force in them will be (except by extraordinary accident) entirely wrong. For the potential thus determined gives charges to the bounding surfaces, whereas there should be none. We must therefore, to get matters right, communicate to the bounding surfaces exactly equal charges of the opposite kind, and distribute them in such a manner as not to disturb the already correctly settled tangential force, *i.e.*, distribute them equipotentially. The field of force will then get right, and the potential will be the sum of the wrong potential and that due to the charges added to cancel those given by the wrong potential.

As regards e in the non-conductors, it may be due to thermal or chemical causes, or be any other impressed electric force. Intrinsic electrization is also included under e; thus, if J be its intensity, $\text{J}=ce/4\pi$ gives us the value of e to correspond. (See p. 230.) So far as producing polar force is concerned, a distribution of e acts in precisely the same manner as would a distribution of electrification of volume density $\sigma=\text{conv.}ce/4\pi$. Here, however, the similarity ceases. It is quite different as regards the displacement and the energy, as e contributes to the displacement equally with polar force, thus $\text{D}=c(e+\text{F})/4\pi$. Sometimes F acts to assist e, but more frequently it is the other way. We should also remark that this *false* electrification σ may, like ρ, the real electrification, have surface distributions over conductors; whenever, in fact, ce is not tangential. The surface density is then $-\text{N}ce/4\pi$. But, unlike a real charge, which can be varied in distribution by influence, the false charge is fixed under the same circumstances. It (σ) should never be referred to as electricity or electrification without the prefix *false*, or some other qualification to distinguish it from Maxwell's electrification or free electricity, which is always discontinuity produced in the elastic displacement, only to be got rid of by conduction, with dissipation of energy in producing heat. In fact, σ is as false electrification as the distribution of electric current round a bar magnet, which would correspond to the same magnetic field, is a false electric current.

Various Expressions for the Electric Energy.

There being any steady state, with impressed forces both in the conductors and in the non-conductors, also electrification and surface charges, let us obtain expressions for the electric energy. We may consider the whole field of displacement as four fields, viz., that in the non-conductors due to impressed force in the conductors; ditto, due to impressed force in the non-conductors; ditto, due to electrification and surface charges; and lastly, that in the conductors. The total electric energy will be the sum of the energies of the separate fields, together with their mutual energies, if they be not conjugate. We shall denote the four fields by the suffixes 1, 2, 3, 4; in all other respects employing the same notation.

1. First, let U_1 be the electric energy in the non-conductors due to e_1 in the conductors. Then,

$$\text{U}_1=\tfrac{1}{2}\Sigma\text{E}_1\text{D}_1=\tfrac{1}{2}\Sigma\text{F}_1c\text{F}_1/4\pi=\tfrac{1}{2}\Sigma\text{P}_1\text{D}_1\text{N}=\tfrac{1}{2}\Sigma\text{Z}_1g_1 \quad . \quad (96)_1$$

Here the first form of U_1 is the form common in all cases, the energy per unit volume being half the scalar product of the force and the displacement. The second form is virtually the same, only putting the displacement in terms of the force, which is polar. These summations of course extend throughout the whole non-conducting regions. The third form is a surface summation over the whole boundary, of half the product of the scalar potential and the normal displacement. The fourth form is also a summation over all the boundary, of half the scalar product of the vector potential Z_1 and the false magnetic current g_1. We have

$$-\text{curl}\text{Z}_1=4\pi\text{D}_1, \qquad \text{VF}_1\text{N}=4\pi g_1.$$

Z_1 is the magnetic impulse, or time-integral of the transient magnetic force during the variable state which would occur if the impressed force were suddenly cancelled, ending in the removal of the displacement D_1 in the non-conductors. Or, without altering the value of the summation, we may take Z_1 to be the time-integral of the actual magnetic force, taken

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negatively, arising from putting on the impressed force, though this is less convenient in general. Should there be no electric current finally, $e_4 + F_4 = 0$, if F_4 is the polar force in the conductor, and therefore $4\pi g_1 = V\mathrm{N}e_4$. In this case also,

$$U_1 = \tfrac{1}{2}\Sigma e_4 \int \Gamma dt,$$

Γ being the true current at time t after starting e_4, so that $\int \Gamma dt$ is the total displacement, elastic and conductive. The other half of the work done by e_4 is spent in heat. Observe that it is necessary for the impressed force in the conductor to reach to its boundary, and to have a tangential component there, for it to be able to set up displacement outside without at the same time producing current in the conductor.

2. Next, let U_2 be the electric energy in the non-conductors due to impressed force in them only. Then,

$$\left.\begin{aligned} U_2 &= \tfrac{1}{2}\Sigma E_2 D_2 = \tfrac{1}{2}\Sigma e_2 D_2 = \tfrac{1}{2}\Sigma Z_2 g_2 \\ &= \tfrac{1}{2}\Sigma e_2 c e_2/4\pi - \tfrac{1}{2}\Sigma F_2 c F_2/4\pi = \tfrac{1}{2}\Sigma e_2 c e_2/4\pi - \tfrac{1}{2}\Sigma P_2 \sigma \end{aligned}\right\} \quad . \quad (96)_2$$

The first form requires no remark. The second results because $E_2 = e_2 + F_2$, and $\Sigma F_2 D_2 = 0$. In the third form Z_2 is the magnetic impulse (of e_2 now, of course), and

$$-\mathrm{curl} Z_2 = 4\pi D_2 \qquad -\mathrm{curl} e_2 = 4\pi g_2;$$

the object of introducing 4π's being to harmonise as well as possible with the usual electromagnetic formulæ. In the fourth form we have the difference of two sums, the first a constant, the second the energy of the field of the polar force by itself, as if due to electrification. In the fifth form the energy of the polar force is expressed in terms of its potential and the false electrification σ. All the summations are taken throughout the non-conductors. There may possibly be surface summations as well, if e_2 exists at the boundaries. All the formulæ in $(96)_2$ are the same as if there were no conductors present.

3. Let U_3 be the common electric energy due to electrification ρ and surface charges q_1, q_2, &c.

$$U_3 = \tfrac{1}{2}\Sigma E_3 D_3 = \tfrac{1}{2}\Sigma F_3 D_3 = \tfrac{1}{2}\Sigma P_3 \rho + \tfrac{1}{2}\Sigma P_3 q \quad . \quad . \quad . \quad (96)_3$$

The first and second forms are identical, the force being polar. In the third form the energy is expressed in terms of the potential and electrification. We may also here employ the magnetic impulse, by a device, but with no utility.

4. Let U_4 be the electric energy in the conductors due to e_4 in them. Then

$$U_4 = \tfrac{1}{2}\Sigma E_4 D_4 = \tfrac{1}{2}\Sigma(e_4 + F_4) D_4 = \tfrac{1}{2}\Sigma e_4 D_4 + \tfrac{1}{2}\Sigma P_4 \rho_4 \quad . \quad . \quad (96)_4$$

Here F_4 is the polar force in the conductors due to e_4, and P_4 its potential; ρ_4 is the interior electrification, if any. Should there be none, D_4 is closed within the conductor, and we may write

$$U_4 = \tfrac{1}{2}\Sigma Z_4 g_4$$

if $\mathrm{curl} Z_4 = -4\pi D_4$ and $\mathrm{curl} e_4 = -4\pi g_4$. It is clear that a similar form exists for the energy in any volume in which there is no electrification, g being represented by the tangential boundary force turned through a right angle, besides the part depending on e_4 if it exist in the volume. (Here e_4 is the same as in the previous concerning U_1.)

5. Lastly, there are the mutual energies. We get rid of U_{14}, U_{24}, and U_{34} at once by observing that the fourth field is in a different place from the first, second, and third, so that these quantities are zero. We can also get rid of U_{13} and U_{23}; the first and third fields, though coexistent, are conjugate, and so are the second and third. Thus,

$$U_{13} = \Sigma D_1 F_3 = \Sigma Z_1 V\mathrm{N} F_3 = 0$$

Z_1 being the same quantity as before. The second summation extends over the boundaries, and vanishes because F_3 is normal to them. Similarly show that U_{23} vanishes. There remains only U_{12}, which does not necessarily vanish.

$$\left.\begin{aligned} U_{12} &= \Sigma E_1 D_2 = \Sigma E_2 D_1 = \Sigma P_1 D_2 \mathrm{N} = \Sigma P_2 D_1 \mathrm{N} \\ &= \Sigma Z_1 g_2 = \Sigma Z_2 g_1 = \Sigma e_2 D_1 \end{aligned}\right\} \quad . \quad (96)_5$$

Here the quantities are the same as before used in treating U_1 and U_2. Finally, U being the complete electric energy in all space

$$U = U_1 + U_2 + U_{12} + U_3 + U_4.$$

Here the first three components of U may be taken together conveniently. Let the impressed forces in the conductors and the non-conductors start at the same moment, and Z be the magnetic impulse, = former $Z_1 + Z_2$, then

$$U_1 + U_2 + U_{12} = \tfrac{1}{2}\Sigma Z g$$

where g = former $g_1 + g_2$, that is

$$4\pi g = -\mathrm{curl}(E_1 + E_2)$$

with the equivalent boundary representative.

Finally, we may, by means of the various conjugate properties, put together the potential results. Let P be the resultant potential from all causes; ρ the electrification density whether in conducting or non-conducting matter, defined by $\rho = \mathrm{div.D}$, including in it surface electrification; σ the density of false electrification, defined by $\sigma = \mathrm{conv.}ce/4\pi = \mathrm{conv.J}$, if J be the (equivalent) intensity of electrisation, *i.e.*, $J = ce/4\pi$, whether in the conductors or not; then

$$U = \tfrac{1}{2}\Sigma eJ + \tfrac{1}{2}\Sigma P(\rho - \sigma) \quad . \quad . \quad . \quad . \quad (97)$$

expresses the total electric energy, the summations being through all space. Notice the minus sign before the false electrification. (97) may also be easily proved directly.

Here, and in any of the summations containing a scalar potential, any constant may be added to the potential, owing to the sum of the electrification being zero, ditto of false. There is an apparent exception when, as may be imagined, tubes of displacement go out to infinity, though this cannot really occur. In such a case, we must choose P to vanish at infinity. But we may get over this by regarding the end of space as an electrified surface. The surface density will be infinitely small, but the charge on it finite, being the exact negative of all the other electrification. Counting it, the constant in P again becomes arbitrary.

We may extend the results to apply to transient states by including in e the electric force of induction, $= -\dot{A}$, if A be such that $\mathrm{curl} A = B$, the magnetic induction. Considering U_1 during the transient state, we find

$$U_1 = \tfrac{1}{2}\Sigma Z_1 G_1 + \tfrac{1}{2}\Sigma Z_1 g_1$$

at any moment, Z_1 being the magnetic impulse that would arise from removing e at that moment, G_1 the *real* magnetic current $\dot{B}/4\pi$ at the moment, and g_1 as before the false magnetic current at the boundary. The first summation extends through the non-conductors. When the steady state is reached, $G_1 = 0$, and Z_1 and g_1 arrive at their before used steady values. Similarly for U_2, U_4, and U_{12} during their transient state.

(To be continued.)

THE STEAM ENGINE INDICATOR.—VII.*

BY AMICE.

The mode of working the indicator has now to be considered —that is to say, the means by which a movement of the indicator barrel exactly synchronous with that of the steam engine piston is obtained. This is not so simple a matter where exactness is required as is usually supposed, and although it is not desirable to insist upon mathematical precision and perfection of fitting of indicator gear, and on the necessity for perfect inextensibility in the communicating cord, it is essential that some thought and care should be bestowed on these matters. It is especially necessary that the indicator card should move in as perfect unison with the piston as though it were attached to it. To obtain this, the gear by which the stroke of the piston is converted into the shorter one of the indicator card should be rigid but light in construction, and the best cord that is made should be used to connect the gear with the indicator barrel. Some engineers prefer to use fine hard brass or steel wire for this purpose. In order to make clear the inaccuracies which accrue in the indicator diagram, through imperfection of the reducing and communicating gear and cord, it is necessary in the first place to describe the arrangements of gear more commonly employed. We will assume that we are dealing with a horizontal engine, although the gear we shall

* For Art. 6, see *The Electrician*, 15th May, 1885.

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describe will, as shown, or with very slight addition or modification, be equally applicable to vertical engines. With few exceptions the horizontal and the vertical include all types, though the multiplication of levers and rods in marine engines sometimes makes it difficult in the usually confined space of an engine room to fit up satisfactory indicator gear. The gear necessary for working an indicator on an oscillating cylinder engine is of a different character, and these diagrams are more difficult to take, in consequence chiefly of the movement of the cylinder.

In Fig. 33 we have a diagram illustrative of a very usual form of reducing gear. Attached to the bolts that hold the guide bars in place are the legs D of a stiff standard for holding the spindle or the pivot p upon which the swinging arm A is pivoted. C is the engine crosshead, and in this a pin is fixed for communicating the movement of the piston to the arm A, the difference between the circular path $x\,x$ of a point in A and the straight path of the crosshead C being accommodated by the slot in the end of A. In some cases the lever A is made of wood, but it can be much more satisfactorily made in metal. The lower end of the arm A moves through a distance equal to the stroke of the piston, and a synchronous movement of shorter range, it is obvious, may be imparted to anything, say an indicator, connected by cord to the arm A at any point, y (not shown), intermediate between C and p. The relation between the ranges of motion of indicator card and of the piston will of course be that of the length p C to $p\,y$. Ordinarily, the cord or wire G by which A communi-

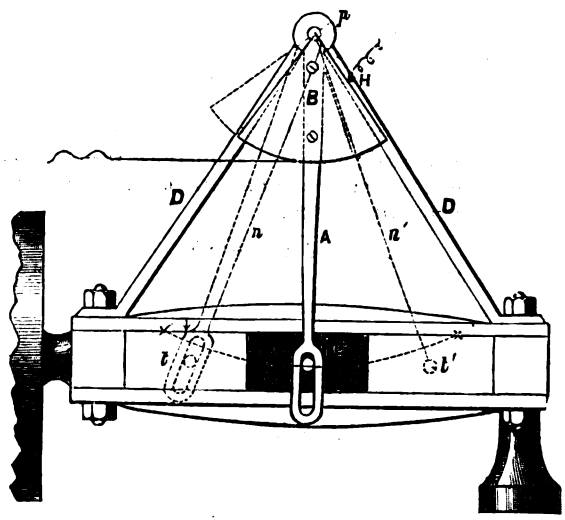

Fig. 33.

cates movement to the indicator barrel is attached to a pin screwed into A or into a piece of wood fastened thereto for the purpose. But the practice is becoming more general to attach a piece of wood of the segmental form shown at B, the radius of which is such as to give the desired length of stroke to the indicator card. Thus, suppose the stroke of the engine to be indicated be 30in., the length p C, say 36in., and it is desired to take diagrams which shall be 4in. in length, the radius of the segment B, or the distance of a pin for the cord from p must be $r = \frac{\text{length of arm A}}{\text{stroke of engine} \div \text{stroke of card}}$, or we have $r = \frac{\text{length of arm A} \times \text{stroke of card}}{\text{stroke of engine piston}}$, giving, in the case assumed, a radius of $\frac{36 \times 4}{30} = 4{\cdot}8$in.

The advantage which attends the use of the segment is that as the cord is always at the same vertical distance from p there is not that loss of horizontal movement in the cord due to the difference between the lengths of the chord and of the arc described, which would result from its following the angular movement of a pin at distance from p = the assumed radius r. The difference between the chord and the arc of the path of the pin is not great, but whether the indicator be near or far from the reducing gear it is sufficient to make an appreciable and sometimes important difference in the diagram. When the gear is very close to the indicator barrel the difference may be magnified. It may, however, be noted that as the pin in the crosshead C moves in its straight path, and the arm A moves in an angular path to n, the pin in the crosshead takes a new place in the slot; it is at a distance from p, which is greater than when the arm A is in midstroke, as shown, by the distance between the pin t and the arc $x\,x$. The length of the arm A is thus virtually increased, the relation between p C and $p\,r$ no longer remains the same, and the result is that the piston of the engine and the crosshead C move through a horizontal distance which is greater than that communicated to that part of A where the pin stood at midstroke, by half the difference between the length of the chord of the arc described by it and of the stroke $t\,t'$. The reality of this

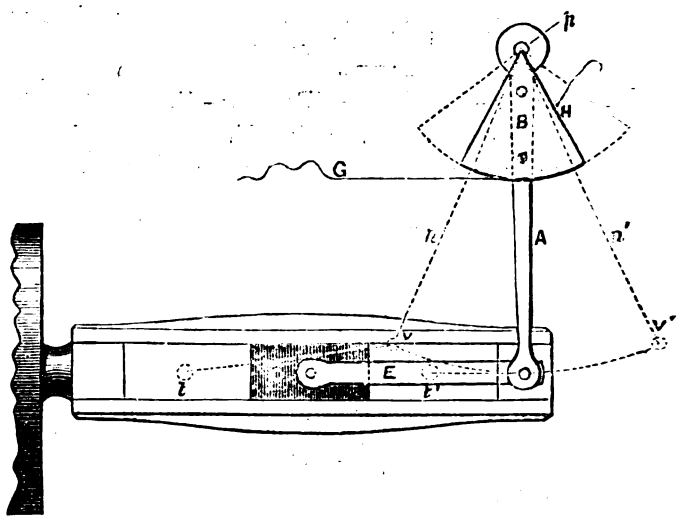

Fig. 34.

movement of the piston without proper corresponding movement of the arm may be easily seen by imagining the arm A pivoted at, say, one-fourth the distance above C, and the slot made of the extra necessary length. This difference it will be seen tends to aggravate the errors

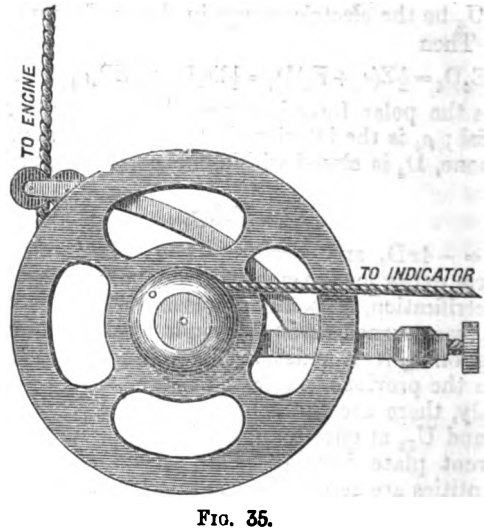

Fig. 35.

produced at either end of the diagram. The error is lessened in very rapid ratio with increase in length in the arm A. As far as the error is due to string attachment to a pin in A at the necessary distance from p, this is overcome by the use of the segment, which must be specially made for each case, as shown; and to avoid, the error as caused by the use of the slotted lever, shown at Fig. 33, the arrangement shown at Fig. 34 is generally preferred. Here the loss of movement is only that due to the angular movement of the connecting rod E, and is equal to the versed sine of the arc described. This, it will be seen may be made quite inappreciable by giving the rods E and A considerable length. It will be observed that

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this loss of movement or inaccuracy at the two ends of the cord happens when the engine piston is moving most slowly, and it becomes an important matter when, as in the case more especially of gas engines, it is desired to find the time occupied in acquiring the maximum pressure. In Fig. 34 the mode of supporting the pivot of the arm A is not shown; but this, as in the case of Fig. 33, may be of any form most easily made, provided it be rigid and the bearings and pins properly fitted. The cord or string G is attached to a pin in the side of the segment at H. By using the segment B the string G may be led to the indicator in whatever position in a vertical plane it may happen to be without affecting the proper movement of the card, the segment having the necessary length of arc, and being attached to A in a suitable position. The segment is shown with its centre line coincident with that of A, but it need not, of course, have this position. Instead of a segment a circular disc may be used.

When a segment or a disc is not used, but only a pin, as above mentioned, to which to attach the string G, care must be taken that a line connecting the pivot p and the pin be normal to the indicator string when the piston is at half stroke, as it is in the diagrams (Figs. 33 and 34).

A form of reducing gear made by Messrs. Elliott Brothers is illustrated by Fig. 35. By means of this there are none of the inaccuracies due to what we may term angular causes already explained, the reduction being effected by the use of rollers or pulleys, the radii of which bear the same relation to each other which must be borne by the arm A and distance r already given. The apparatus necessitates different wheels for different strokes and lengths of diagram. It may be attached direct to the indicator, or elsewhere if more convenient, and is a handy form for oscillating cylinder engines. It necessitates the use of two strings or wires instead of one, and thus, although it avoids all the levers and supports we have described, it incurs whatever objections may be made to strings or wire. In all cases care must be taken that the string G is of the proper length, so that the indicator barrel is not pulled to or let back to either of the stops.

THE NEW SIXPENNY TELEGRAM FORM.

We are able to present our readers with a copy of the form which will come into use for the sending of telegrams at the reduced rate on the 1st of October. It will be seen that the chief difference between the old and the new form is that on the latter there is no space provided for the name and address of the sender. This information, if it is to be signalled, will have to be added at the end of the message like a signature. A space is provided at the back of the form for the insertion of the "Name and Address of Sender (for Reference Only)," when these particulars are not to be telegraphed; but their insertion anywhere apparently is not compulsory. The copy here given is rather less in size than the original :—

A.

Prefix.....Code.....

POST OFFICE TELEGRAPHS.

(Inland Telegrams.)

No. of Message.....

For Postage Stamps.

The Stamps must be affixed by the Sender.

Office of Origin and Service Instructions.

Words.

Charge.

Sent

At.....M.

To.....

By.....

A Receipt for the Charges on this Telegram can be obtained, price Two-pence.

The **Name** and **Address** of the **Sender**, or either of them, *if to be telegraphed*, must be written at the End of the Message; if not to be telegraphed, they should be written in the Space provided at the Back of the Form.

12 words, **6D.**

TO

Every additional word **½D.**

Every word telegraphed is charged for, whether in addresses or text.

NOTICE.—This Telegram will be accepted for transmission subject to the Regulations made pursuant to the 2nd Section of the Telegraph Act, 1885, and to the Notice printed at the back hereof.

It will be seen that the marginal note relating to charges makes no mention of any change in the rules for counting. We believe, however, that material concessions in the matter of compound words will be made, especially in the addresses where compound names of towns, districts, and places are of frequent occurrence; and these in future will be counted each as a single word. Not only this, any group of figures not exceeding five will be treated as one word—a very considerable boon to the general public as well as to business men.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Cheques and P.O. Orders to be made payable to C. H. W. BIGGS.

Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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LIGHTHOUSE EXPERIMENTS AT THE SOUTH FORELAND.

The delay in publishing the results of the experimental tests which were completed last winter at the South Foreland has been partly due, no doubt, to the circumstance referred to in our issue of the second week in December. Besides the regular observations of those entrusted with the experiments, observations were invited from captains of vessels passing the Foreland, and books were provided in which careful records could be made. Some time must necessarily have elapsed before these documents could be got in; but it is satisfactory to note that the general conclusions which we indicated last February as having been arrived at by the officials on the spot have apparently not been disturbed in any degree by the later evidence afforded by passing ships. These conclusions, so far as the efficiency of the Electric Light is concerned, were entirely satisfactory. It was stated at that time that with their lights at full power gas and oil failed to project any illumination beyond ten miles, whereas the beam of light from the electric arc was pronounced good at fourteen and a half miles. The full official report is not yet made public, but such portions of it as have been already supplied to the press substantially bear out this statement, as also the contention that in penetrative power through fog, rain, or haze, the electric light was superior to that of either gas or oil.

We gave full details of the apparatus and appliances employed for producing the electric light for these trials several months ago, and need not recapitulate them here. Apart from the special question of lighthouse illumination, they were interesting as having established the superiority of certain classes of carbons and the defects of others. Everything was no doubt of the best in other respects, though some may say not of the very best that might have been furnished for such a thoroughly representative trial. But we have no reason to complain on this score; for there is not a doubt as to the supreme excellence of the gas and oil appliances respectively which were pitted against the electric current. The relative merits of the Wigham and Douglass systems have long been in dispute—a dispute with which we have nothing to do here—but there is no question as to their being the most powerful appliances for long distance illumination of their kind that are anywhere known. Thus the competition was a severe one; and that the electric light, which is comparatively in its infancy, has fared so well in the contest will be highly gratifying, though not in the least surprising, to our readers.

The conditions of the trials appear to have been unexceptionable. Three towers of similar height were erected at distances apart sufficient to prevent the blending of the lights when exhibiting together. To a large extent the observations were taken on land, the flat unbroken country of the district favouring this arrangement, where competent observers were stationed at suitable points both for taking eye measurements and more accurate records with the photometer. At longer distances the coastguardsmen by the shore towards Dover, and the lightsmen on board the several neighbouring lightships out at sea, were called into requisition. Upwards of 4,000 trustworthy records were taken during the summer and winter months of last year, and tabulated analyses have now been drawn up upon which decisive conclusions can be based. Between seven and eight hundred of these observations were made with the distinct object of comparing the electric light with the highest powers of the other two lights, and the result was that, under all conditions of weather, it showed an advantage of from 35 to 40 per cent. over them, whether as a fixed or revolving light.

An important section of the Report deals with the subject of fog and mist; and here the verdict is hardly less favourable. It has often been stated, and it is, we believe, commonly supposed, that the electric light is almost useless, or, at all events, less useful than gas, in foggy weather. But the experiments at South Foreland dispose of this error. With one or two exceptions, the reasons for which are stated, electricity proved itself superior to either gas or oil under every atmospheric condition. The season, it is true, was not favourable to the observations under this head—that is to say, the year was unusually free from dense fog and mist. But such as came under observation revealed the fact that the most powerful lights of every kind become invisible in thick fog at very short distances, and their relative difference of penetrating power is so small as to be not worth considering. In weather not absolutely foggy, however, but thick with mist or haze, the electric light is seen so much farther as to be of practical advantage to the mariner. The greatest visibility at short distances, it would seem, is obtained by sending the current from one or more machines through a single arc.

The tables of exact measurements furnished by Mr. Dixon lead to the same general conclusions. Gas and oil are equally affected by atmospheric variations; and he adds that electric light is absorbed more largely by haze and fog than either; but this only shows that the former can spare its light more liberally, for Mr. Dixon concludes that in all weathers and at all distances the electric light proved superior to both its competitors. Moreover, the Committee in summing up the evidence are even more explicit, describing the electric light as having

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the greatest penetrative power in fog; and the first part of their Report concludes with the declaration that for salient headlands, important landfalls, and places where a very powerful light is required, electricity offers the greatest advantages. For other situations the decision is in favour of mineral oil, on the practical grounds that, whilst its inferiority to gas as an illuminant is hardly appreciable, its superiority in point of cheapness is very considerable. The difference in expense alone would not have weighed with the Committee if the differing efficiency had been worth considering. We may therefore conclude that for the future lighthouse illumination will be shared between oil, with a wider if humbler field of operation, and electricity, which will occupy, perhaps, the fewer but far more commanding situations. The cost of installing and maintaining it is, judged by the experiments at North Foreland, far in excess of oil, and probably always will be; but extra cost has not precluded the use of gas hitherto, nor will the introduction of electricity be so hindered. It is at this moment being permanently installed on the Isle of May at the important entrance to the Firth of Forth; and we have no doubt that it will rapidly come into use wherever its superiority may in any degree contribute to the safety and well-being of the seafaring world.

CORRESPONDENCE.

IDEAS, WORDS, AND SYMBOLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: However desirable it may be that writers on electrotechnics should use a common notation, at least as regards the frequently recurring magnitudes concerned—which notation should not be a difficult matter to arrange, provided it be kept within practical limits—it is perhaps more desirable that they should adopt a common language, within the same practical limits, of course. For whilst the use of certain letters for certain magnitudes requires no more explanation than, for instance, "Let us call the currents C_1, C_2, &c.," it is otherwise with the language used when speaking of the magnitudes, as more elaborate explanations are needed to identify the ideas meant to be expressed.

As regards electric conduction currents, there is a tolerably uniform usage, and a fairly good terminology. It is seldom that any doubt can arise as to a writer's meaning, unless he be an ignoramus or a paradoxist, or have unfortunately an indistinct manner of expressing himself. I would, however, like to see the word "intensity," as applied to the electric current, wholly abolished. It was formerly very commonly used, and there was an equally common vagueness of ideas prevalent. It is sufficient to speak of the current in a wire (total) as "the current," or "the strength of current," and when referred to unit area, the current density. (In three dimensions, on the the other hand, when everything is referred to the unit volume, and the current density is meant as a matter of course, it is equally sufficient to call *it* the current.)

It is a matter of considerable practical advantage to have single words for names, instead of groups of words, and it is fortunate that the existing conduction current terminology admits of very practical adaptation this way. Thus, "specific resistance" may be well called "resistivity," and specific conductance "conductivity," referring to the unit volume. Resistivity is the reciprocal of conductivity, and resistance of conductance. When wires are in parallel, their conductances may be more easy to manage than their resistance. We have also the convenient adjectives "conductive" and "resistive," to save circumlocution.

Passing to the subject of magnetic induction, there is considerable looseness prevailing. There is a definite magnitude called by Maxwell "the magnetic induction," which may well be called simply "the induction." It is related to the magnetic force in the same manner as current density to the electric power. ($B=\mu H$.) Their ratio μ is the "magnetic permeability." This may be simply called the permeability, since the word is not used in any other electrical sense. Induction and permeability may not be the best names, but (apart from their being understood by mathematical electricians) they are infinitely better than the long-winded "number of lines of force" (meaning magnetic) and "conductivity for lines of force," the use of which, though defensible enough in merely popular explanations, becomes almost absurd when the electrotechnical user actually goes so far as to give them quantitative expression. Conductivity should not be used at all, save in pointing out an analogy. It has its own definite meaning.

"Permeability," however, does not admit of such easy adaptation to different circumstances, like conductivity. Permeability referring to the unit volume, the word permeance is suggested for a mass, analogous to conductance. We have also the adjective "permeable." By adding, moreover, the prefix "im," we get "impermeable," "impermeability," and "impermeance," for the reciprocal ideas, sometimes wanted. Thus impermeability, the reciprocal of μ, would stand for the long-winded "specific resistance to lines of magnetic force." (The permeance of a coil would be $L/4\pi$, if L is its coefficient of self-induction. In the expression $T=\frac{1}{2}LC^2$ for the magnetic energy of current C in the coil 4π does not appear, whilst it does in the form $T=\frac{1}{2}$ magnetomotive force × total induction through the circuit $\div 4\pi$. It is $4\pi C$ that is the magnetomotive force, and LC the induction though the circuit. Thus we have oppositely acting 4π's. I may here remark that it would be not only a theoretical but a great practical improvement to have the electric and magnetic units recast on a rational basis. But I suppose there is no chance of such an extensive change.) It must be confessed, however, that these various words are not so good as the corresponding conduction current words.

But now, if, thirdly, we pass to electric displacement, the analogue of magnetic induction (noting by the way that it had better not be called the electric induction, on account of our already appropriating the word induction, but be called the displacement), the existing terminology is extremely unsatisfactory; and, moreover, does not readily admit of adaptation and extension. Corresponding to conductivity and permeability we have "specific inductive capacity," or "dielectric constant," or whatever it may be called. I usually call it the electric capacity, or the capacity. It refers to the unit volume. But here it is very unfortunate that it is not this specific capacity c (say), but $c/4\pi$ that is the capacity of a unit cube condenser (such that charge = difference of potential × capacity). D, the displacement, is the charge (+ or −, according to the end), and we have $D=cE/4\pi$, E being the electric force. We may get over this trouble by putting it thus, $D=sE$, and calling s (or $c/4\pi$) the specific capacity. Then the capacity in bulk is got in the same manner as conductance from conductivity.

Supposing we have done this, there is still the trouble that capacity gives the extremely awkward inverse "incapacity," and the adjectives "capacious" and "incapacious," besides not giving us any words for use in bulk, like conductance and resistance. And, in addition, the word capacity is itself rather objectionable, as likely to give beginners entirely erroneous notions as to the physical quality involved. It is not that one dielectric absorbs electricity more readily than another. Electric displacement is an *elastic* phenomenon, one dielectric is more yielding (electrically) than another. The reciprocal of s above is the electric elasticity, the electric force required to produce the unit displacement. Thus s should have a name to express the idea of elastic yielding or distortion, and its reciprocal also a name (not strings of words), and they should be readily adaptable, like conductivity, &c. (Perhaps also a better word than permeability might be introduced, although, as we see, it is tolerably accommodative.) Displacement itself might also be replaced by another word less suggestive of bodily translation; although, on the other hand, it harmonises well with "current," the displacement being the accumulated current, or the current the time-variation of the displacement.

All these things will get right in time, perhaps. Ideas are

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of primary importance, scientifically. Next, suitable language. As for the notation, it is an important enough matter, but still only takes the third place.—Yours, &c.,

OLIVER HEAVISIDE.

TREATMENT OF SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Without wishing to detract from the merits of Sir David Salomon's experiments, I would point out that it is absolutely essential that the cells should regularly be fully charged and not left exhausted. We made several conclusive experiments both with thick and thin plates, which were charged continuously for long periods, and found that the working condition of such cells was apparently not in any way affected.

Our working instructions will be found to refer not to cells which are charged before the rest, but to any cell which may be lower than the remainder.

In this case we point out the necessity of charging it with the rest, and cutting it out of the discharging circuit in order to get it again fully charged.

Although the resistance recommended by Sir David might be used with impunity in such skilled hands as his own, I should be very sorry to see it adopted in regular work; and the gain is not very apparent, as the energy is equally wasted whether it is consumed in the production of heat or gases.

I shall be happy to show Sir David some of the overcharged plates referred to, which are a clean dark brown colour throughout, and although I shall always be delighted to hear the results of his experiments with our cells, I trust he will not take it to heart if exception is taken to such of his conclusions as would be likely to interfere with the satisfactory working of the cells when in unskilled hands.—Yours, &c.

BERNARD DRAKE, Managing Engineer, Electrical Power Storage Company (Limited).

DOUBLE POLE SWITCHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having had an opportunity of carefully examining the American system of electric light fittings and comparing their efficiency with those employed here, may I be allowed to make a few remarks on your correspondent's letter?

Double pole switches are the exception and not the rule in the United States. They were not fitted in many of the installations of the Edison Company which I visited last year, and are not used at all by the other important companies. The double pole Edison cut-out has been found of service in preventing accidents due to ground circuits or contact with telephone or telegraph wires, but it is clumsy in appearance, and a short circuit may occur on the block itself between the two fusible plugs.

Mr. Woodbury, of the Boston Fire Underwriters' Union, recommends "a separate cut-out to be placed on each wire," but it is only in exceptional circumstances that more than one wire of the circuit is protected.

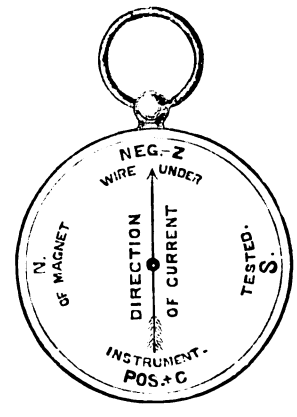
I do not think English electrical engineers would profit by using American fittings; at any rate, none of the switches exhibited at Philadelphia were superior as regards workmanship to the well known type made by Crompton, Lundberg, or the Globe Company. It is true that the Edison main switches are generally constructed with more pleasing exteriors and ornamental cases, but they are very much dearer than those in general use here. Although double pole switches may be advisable sometimes, I think the needless complication of the fitting may be avoided by fixing a separate plug switch on one lead, to be used on emergency only. In conclusion, allow me to state that the idea is not new, as I exhibited a switch with connections to open the circuit on both wires at the Crystal Palace Exhibition, and I believe a large number have been manufactured.—Yours, &c.,

August 26th. KILLINGWORTH HEDGES.

A NEW TESTING INSTRUMENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I beg to enclose a sketch of a little testing instrument which may commend itself to your readers. This simple apparatus consists of a floating-card compass, with the card suitably lettered for the required purpose. When placed over a wire conveying a current it at once indicates the direction, &c., of the same, and if used to test a magnet, shows the north or south pole. These can be retailed at one shilling



each, if a fair number were required to make it worth while for a manufacturer to take them up.—Yours, &c.,

Brighton, August, 1885. M. VOLK.

[We fear that, as the accuracy of this instrument would depend upon the needle not losing its magnetism, for the purpose, at all events, of testing the direction of a current from a dynamo, that Mr. Volk's very ingenious contrivance would not be quite so reliable as it might be.—ED. *E.*]

THE HEART OF THE ENGLISH TELEGRAPHS.

A few days ago, by the courtesy of Mr. May, the acting Controller of the Central Telegraph Station during the absence of Mr. H. C. Fischer, we were enabled to pay a visit to the Heart of the English telegraphs, or, in more prosaic language, to the great central station of the Post Office Telegraphs. This mammoth building, which, it will be remembered, superseded the less elegant and commodious structure in Telegraph-street some ten years or so ago, stands upon a site exactly opposite St. Martin's-le-Grand, and was erected from the designs and under the superintendence of Mr. James Williams, of Her Majesty's Office of Works and Public Buildings. It was built by Mr. William Brass, whose tender amounted to £129,718; and the site cost £300,000, making in round figures a total of £430,000. The foundations were commenced in 1869, and the first block of stone was laid by Mr. Ayrton on the 16th of December, 1870. In shape the building is rectangular; its frontages, which are composed of the hardest Whitbed Portland stone, enriched by the chisel of Mr. Burnie Philip, extend some 286ft. on the St. Martin's-le-Grand and Bath-street sides, and on the Newgate-street and Angel-street angles about a hundred and forty-two feet less. The whole building as originally designed rose some 84ft. from the street level, on a solid base of granite from the famous De Lank quarries, and was four-storied, exclusive of the underground premises.

During the last two years, however, a fifth story has been added, in which is located the metropolitan gallery; and additional premises have also been acquired in Angel-street for the accommodation of the male and female staff. The basement of the main building is partly occupied as office rooms, department of telegraph engineers, and contains the very large battery room. The third floor is appropriated to the executive officers of the staff, &c., and on the fourth and fifth are the instrument rooms, the rest of the building being taken up by the postal authorities. In the north court are the beam engines employed in compressing and exhausting the air for the pneumatic system, and in the south court adjacent are

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situated the mechanical repairing shops. From here a huge shaft ascends, its cap being some ten or fifteen feet above the roof, whence, we are informed, during a more than usually strong wind it nods in a threatening manner, as if half inclined to demolish the puny mortals below who persist in sullying its interior with even the best, if there be a best, of smoke.

Having ascended by easy stages to the proper altitude, we resigned our hat and umbrella to the care of an imposing personage in scarlet, and under what proved to be very able guidance entered the principal instrument room. The effect was bewildering in the extreme. We had imagined in our ignorance that we were about to emerge from the solitude of the corridors upon a scene of indescribable noise, if not of confusion. We had pictured to ourselves (little appreciating the admirable system that prevails at the Central Station) the simultaneous clicking of a thousand instruments, and the tumult which, however subdued, must seemingly accompany the united operations of twice that number of people. Here, however, save for a hum as of a multitude of distant bees, nothing was perceptible to the ear. Order, method, almost quietude, reigned supreme. There was a general air of relaxation, of quiet ease, about the place that, upon the first glance, conveyed a very false impression as to what was actually being done by the busy workers, and it was not until we began to look into details that we fully recognised the fact that each of the skilled operators before us was being taxed to perhaps the full extent of his or her energies. As might have been predicted, upon the exclusive adoption of the Morse code by the Government authorities many of the instruments which did such good work in the past have gradually died out of use; the sounder and the Wheatstone automatic transmitter and receiver replacing them, and with advantage in every case where economy and accuracy, combined with great speed, are ruling considerations. In all "T. S." there is not a Hughes type-writer and but a single Bright's bell. Some at least of our readers, however, will remember how efficient an instrument the bell was in conjunction with the old "magnetic" code, and how often on busy circuits, such as the London and Liverpool Stock Exchange and the Leeds and Belfast wires, it was resorted to when a block somehow or another had to be worked off. Of the A B C instrument there are but four left, one of them, by the way, devoted to the "Universal Provider," and not one double needle. There are, however, 161 single needles at work on the minor metropolitan circuits.

To return to our subject, the instrument rooms, to give a cut-and-dried description of them, are divided into two principal portions, the provincial and the metropolitan. These main sections are again sub-divided into divisions and groups, viz., ten in the provincial, exclusive of the news division, and the same number in the metropolitan department. The north-east, north, and north-west wings of the instrument room are entirely set apart for the instruments communicating with the various metropolitan and suburban telegraph offices, of which there are over 400. In the metropolitan section there are 388 instruments, made up as follows:—50 duplex sounders, 75 duplex Morse, 71 ordinary Morse, 55 sounders, 133 single needles, and four A B C's. The remaining wings and the central gallery are devoted to the circuits communicating with the provinces and Scotland and Ireland, and the news and special racing circuits, the latter being apart by themselves in the south western wing adjoining the rooms occupied by the Intelligence Department, where news and other matter is passed on its receipt and prepared for further dissemination and delivery. The north of England, Ireland, and Scotland are spoken with from the southern gallery, and the southern, eastern, western, and the home counties from the south eastern and central gallery. There are numerically fewer instruments in the provincial than in the metropolitan section, but they embrace a large number of the fast-working automatic apparatus. In all there are 329 instruments in that section, of the following descriptions:—32 Wheatstone duplex, 58 Wheatstone automatic, 17 quadruplex (of these the Birmingham instrument, a sounder, negotiates about 250 messages per hour), including one spare; 18 duplex recorders, 93 duplex sounders, 45 Morse, 37 sounders, 28 single needles, and one Bright's bell. The number of messages dealt with each day at the central station alone ranges between 45,000 and 60,000, nearly half of which are transmitted messages, and are therefore practically two telegrams, although only counted one in the total. Besides the large bulk of the traffic passing between the provinces and London, there are daily from 5,000 to 7,000 local messages, *i.e.*, emanating from one part of London or the suburbs for delivery in another part, besides a vast quantity of news messages, which on busy parliamentary nights not unfrequently exceeds half a million words per night.

In conclusion of our cut-and-dried remarks, we may mention that the total number of telegraphists employed in this gigantic establishment is 1,800, of which no fewer than one-third are females.

On entering the provincial room at the news division end a feature of interest presented itself in the long array of pneumatic punchers which are used to prepare the "slip" for the Wheatstone transmitters. These have been improved upon from time to time until they are seemingly as perfect as human skill can make them. The pneumatic puncher is of course by no means new, but ten years ago it was thought impossible to punch more than one slip at a time with each set of apparatus. A very ingenious arrangement has, however, been contrived by which three or more slips can be punched simultaneously either by using triply-wound paper or by super-adding one puncher upon another in a frame provided for them. Of the transmitters, we were kindly informed, there are on busy nights about seventy going at once, of which about thirty-five are duplexed. Every effort has apparently been made to ensure economic working, where economy has been found to be compatible with efficiency. The duplex and quadruplex sounders, the multiple punchers, and the "fork lines" are in themselves sufficient evidence of this. The latter are more properly junction circuits, Dublin, Cork, and Belfast being included in one and the same circuit, and so on. Each Wheatstone receiver, however, is arranged for ordinary duplex working during times of decreased pressure, a simple switch cutting out or putting in the transmitter as required.

Another very interesting piece of mechanism is the automatic "chronifer" for transmitting the Greenwich time signals to various towns in the United Kingdom, about 40 of the principal of which we observed were connected up. Every clock in the building is also synchronised by means of this very ingenious apparatus. Close by it was the switch-board, which, together with its prototype in the metropolitan room, presented an apparently interminable array of connections.

The central station is, however, by no means entirely dependent upon electricity for the dissemination of, at all events, a portion of its traffic. A most important and most useful auxiliary is the pneumatic tube. To this apparatus is due also in some degree the absence of anything like confusion, for it enables a very large number of collectors to be dispensed with, tubes conveying the messages between the different divisions and departments. In Telegraph-street, if we remember rightly, much the same sort of thing was done by means of overhead double shafting, driven by steam-power, the the messages being pushed between the bands and transmitted to the collecting tables. Of these local tubes there are in all some 28, of the ancient pattern—that is to say, with the form of valve designed by Mr. Latimer Clark. Of the more important ones connecting the central station with the principal offices in the City and the West End there are 30, worked on the double sluice valve system of Messrs. Siemens and Halske. Some of these are intermediate, Cannon-street and Lower Thames-street being, for instance, on one tube, Cornhill and Royal Exchange on another, Commercial Sale Rooms and Lothbury on another, &c., &c. A few of the branch stations are fitted with two tubes, one "up" and the other "down," or in other words, one vacuum and the other pressure. Several of the cable companies are also connected with the central office, for which purpose there are eight tubes. The longest lines are those working to the offices at the House of Commons, West Strand, and Lower Thames-street. The length of the former is about 2½ miles, and carriers containing

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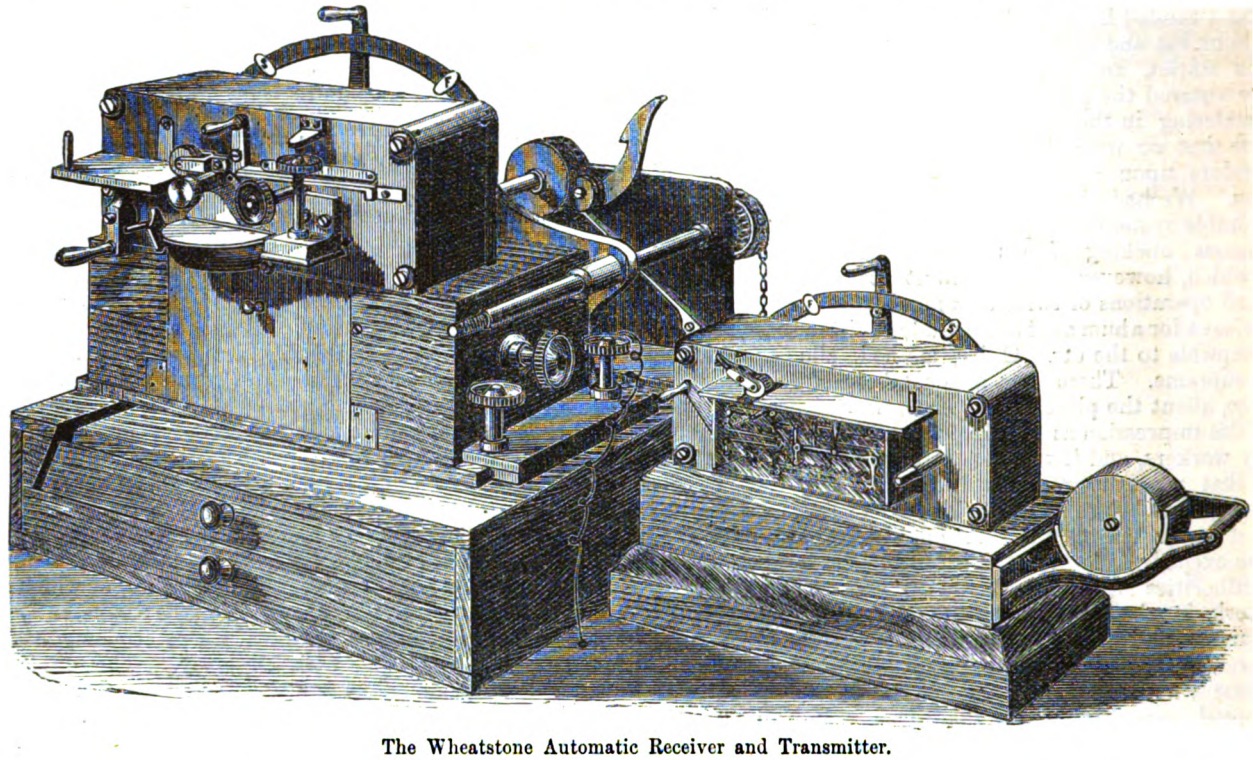
messages are blown through in from five to seven minutes. The latter are about two miles in length, and the times occupied in transit are from 3½ to 4½ minutes. The tubes to the Stock Exchange and Charing-cross are somewhat larger than the others, being of a diameter of three inches. In connection with the latter is a device fixed midway in the line,

Having got so far, and becoming, in truth, a little afraid of wearying our kind *cicerone*, we made haste to reclaim our impedimenta and descend to the basement, where still more wonders awaited our inspection.

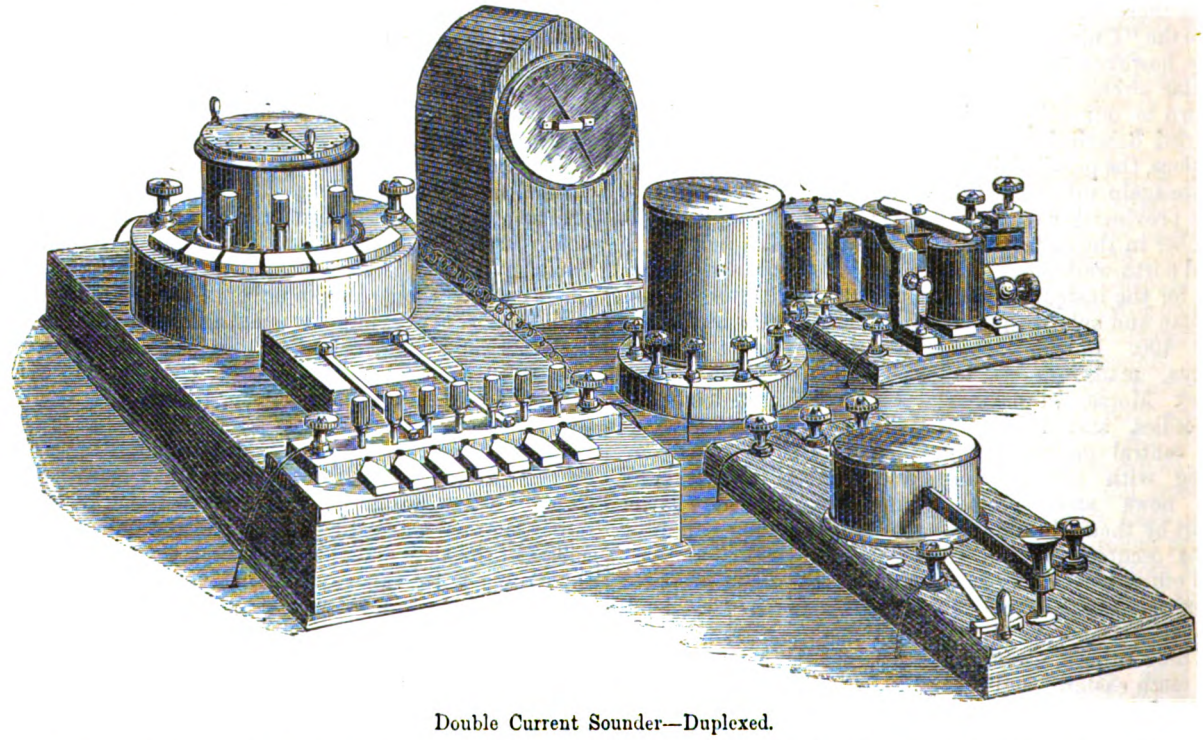
Here, again, we found economy and utility exemplified by a paper-making machine, busily engaged in grinding old



The Wheatstone Automatic Receiver and Transmitter.

which, upon being touched by the carrier in transit, electrically indicates its position to both stations; and another carrier is then, to avoid unnecessary delay, immediately sent forward. This line is one mile eight hundred yards in length, and the

message forms into pulp, which, after being passed on to a vacuum pump for the purpose of having all the moisture extracted from it and forced through a pair of rollers, finally emerged in the shape of coarse paper. The real object of this



Double Current Sounder—Duplexed.

carriers occupy about four minutes in transmission. To the Stock Exchange, a distance of 700 yards, a higher rate of speed has been arrived at, fifty seconds in this case sufficing for the journey. The tubes, we believe, are served by messengers, under the control of responsible persons.

machine is, no doubt, the effectual obliteration of the messages. Close at hand were two 12 horse-power Easton and Anderson's beam engines at work in connection with an artesian well 630ft. in depth; and two small dynamos—one Elwell-Parker and one Siemens—giving a difference of potential at the

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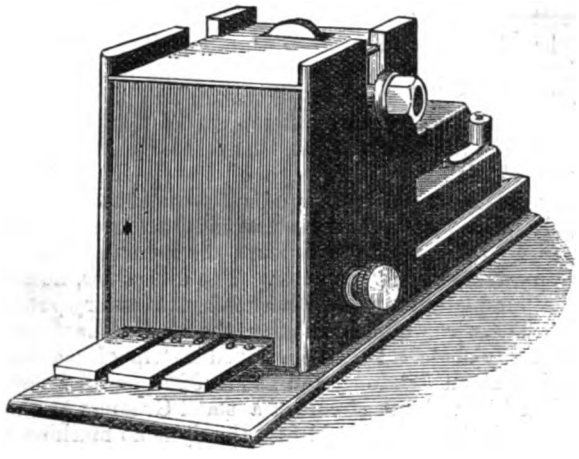
terminals of about fifty volts. These are used to charge accumulators for experimental purposes. At present there are seventy-eight Elwell-Parker accumulators under trial, and these, we were informed, give greater satisfaction for electric lighting purposes than any others that have as yet been tried. For telegraphy, Dr. Tribe's cells have been found to yield excellent results, and of these there are at present about eight, working thirty of the metropolitan circuits. Ranged about the main battery room, which serves the provincial section, are approximately 30,000 cells, including 12,000 Fullers, and 1,500 agglomerate Leclanchés, the latter being used for bells and local signals, as well as for the "chronifer," which has a battery of 140 cells. For all circuits under one hundred miles the Daniell is used, for greater distances the Fuller.



Pneumatic Puncher.

To look after this army of pots, and what not, there are, to the credit of everybody concerned be it said, but thirteen men, and we are glad to be able to testify to the admirable and systematic way in which it is done. For the benefit of those of our readers who do not fully recognise what an amount of thought and labour must have been bestowed upon the organisation of this department, we may mention that each group of cells bears a special number both on the shelf belonging to it and upon the test-board, and is brought direct to one of the 4,000 terminals on that board. For these connections 470 miles of wire have been used in the main battery room alone, and probably as much more in the connections with the test-board in the provincial instrument room; while the shelves upon which the various cells rest are about three miles in length.

In another and smaller room near by are the batteries for supplying the metropolitan circuits, each line taking about five elements. Here, in addition to the Fuller and single Daniell, we noticed some of the old pattern trough Daniells, which at one time were put forward as types of perfection.

Thence, from the domain of current, we wandered into the region of pneumatics, or rather into the really magnificent engine room, where four 50 horse-power (normal) beam engines, really models of workmanship and construction, serve to actuate the pneumatic system in active operation above. Three of these engines only were in action, one being always in reserve; two are used for exhausting, and the other in compressing the air. The room itself was everywhere bright, with the brightest of steel gratings. Each of the enormous beams of the engines rose and fell between three rows of double columns, conspicuous both for ornament and strength. On one of the walls three gauges indicated the steam and air pressure and the vacuum. These were respectively 50, 15, and 19lb. on the square inch. Below the gratings were to be seen the cylinders and the large air-pumps; while, above, a sleepy though civil attendant, who informed us that the normal horse-power was rarely, if ever, exceeded, completed the list of objects, inanimate and human. The air reservoirs formerly in use have been dispensed with, an 18in. pipe, of square section, connecting the pumps with the tubes in the various galleries, and forming a very efficient substitute for the more cumbersome apparatus.

Such was our experience of a visit to what we have called the Heart of the English Telegraphs; and if any of our readers take exception to the metaphor, we can only advise them to follow in our footsteps and see for themselves if the similitude is overdrawn.

THE LIFE OF INCANDESCENT LAMPS.

The following is a statement of the life of incandescent lamps at the Royal Courts of Justice from January 10th, 1885, to present vacation. The lamps are Edison-Swan 85 volts 20 nominal candle-power. The actual number of hours burning were not recorded until the beginning of this year :—

Name of Circuit.	No. of lamps on Circuit.	No. of hours burning. Average.	Total lamp hours.	Lamps changed.				Remarks.
				Burnt out.	Broken lugs.	Accidental breakages.	Total.	
Courts	446	155	69,130	15	2	2	19	Some Courts burn more than others.
Corridors	159	197	31,323	18	2	3	33	
All Day Circuit	56	1,298	72,688	60	1	2	63	
Engine Room	16	1,298	20,768	27	1	9	37	E.M.F. kept at 87 in engine room.
New All Day Circuit	28	480·5	3,454	*1	—	1	2	*Carbon broke first day.
Total	705		197,363	121	6	17	144	

Average life of lamps burnt out 1631·1 hrs, or average life, calculating losses from all sources, 1370·43 hrs.

We may add a few remarks as to the installation at the Law Courts under the charge of Mr. Grundy. After the installation was started last year, it was found desirable to extend it, partly on account of the dynamite scare and partly from other reasons, so some 70 lights were added to the all-day circuit. There are usually 100 lights running all day, fed from two Mather and Platt's dynamos, giving 90 volts and 70 amperes at 1,000 revolutions. These machines are connected to a Crompton collecting switch-board, which allows either or both machines to be worked at will. The dynamos are driven by a 10 horse-power vertical engine running about 165 revolutions. The all-day circuits, the engine room, and some of the courts are fitted with Grundy and Ready's holder (*vide The Electrician*, p. 182, July 17), and others will be fitted during the vacation. During the year's work it is gratifying to learn that only one hitch has occurred in the lighting, and that was through the slipping of a belt, which was remedied inside of two minutes. The table of the life of the incandescent lamps at the Law Courts is perhaps the most important ever published, in that it comes from an absolutely independent source. We have no hesitation in saying that a great advance is shown in the manufacture of lamps by these tables, and that lamps having an average life of 2,000 hours are to be expected in the immediate future.

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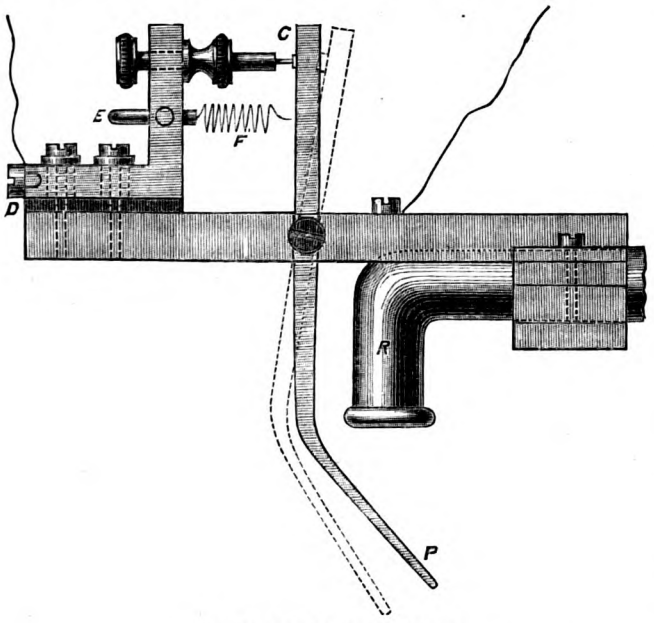
AN ALARM TO REPORT FAILURE OF WATER SUPPLY IN AN OTTO GAS ENGINE.

BY PROFESSOR PH. CARL, MUNICH.

During the past winter it was several times my misfortune to have the water supply in the neighbourhood of my laboratory cut off, without receiving any previous notice of the same. One of the results of this was a failure of water for my Otto gas engine. On making inquiries I discovered that the same thing frequently occurred in other places where gas engines were in use, and this led me to design a contrivance,* which put an alarm bell into action at the instant when the water ceased to flow, and so enabled any overheating of the gas engine and injuries thereby resulting to be prevented in time.



Gas Engine Water Indicator.

This very simple arrangement, represented full size in the annexed figure, is screwed down directly to the water outflow pipe R. Before the aperture of the pipe is a lever with a disc, P, on one arm, on to which the issuing water infringes, thereby keeping the lever in the position indicated by the dotted lines. The effect of this is to break the platinum contact at C, and so interrupt the circuit of an alarm bell placed in a suitable position. Suppose the water ceases to flow, the spring F comes into play, contact is made at C, and the bell keeps on ringing till some one comes to stop it.

It is almost needless to remark that the disc D and the pin E are composed of insulating material such as vulcanite.

A STANDARD OF LIGHT.†

BY PROF. J. TROWBRIDGE.

The discussion in the Paris Conference of 1881-4 upon the subject of a standard of light, which resulted in the adoption of the light emitted by a surface of platinum at the point of solidification, seemed to assort ill with the discussions which led to a reaffirmation of the C.-G.-S. system of absolute physical units, and a recognition of the relations between work and heat and electrical energy.

The solidification point of platinum may be a fixed point in nature; but it has not been shown how this fixed point can be connected with the great web of physical instruments which have been woven by Weber, Helmholtz, Thomson, Maxwell, and other physicists. It is true that during the discussions of the Conference reference was made to a proposition from Schwendler that the light emitted by a strip of platinum, rendered incandescent by a known electrical current, should be taken as a standard. The proposition, however, received little support, and the Conference finally adopted the light emitted by solidifying platinum as a standard.

It seems highly desirable that any standard of light which may be adopted should be connected with the present system of absolute measurements. The suggestion of Schwendler, therefore, seems to merit more attention that it has received. The suggestion of employing the light from a strip of platinum, rendered incandescent by an electrical current, is really due to Dr. J. W. Draper, of New York, who, in 1847, enunciated it as follows:—"A surface of platinum of standard dimensions raised to a standard temperature by a voltaic current will always emit a constant light. A strip of that metal one inch long and one-twentieth of an inch wide connected with a lever, by which its expansion might be measured, will yield at 2,000 degs. a light suitable for most purposes."

It has been urged against this standard that different specimens of platinum will emit different amounts of light with the same difference of potential; and that it would be difficult to carry out a measurement of the light and the strength of the current at the same instant. With a view to obtaining a knowledge of the practical difficulties in this measurement, I interposed a fine platinum wire between the poles of a battery and endeavoured to measure the light emitted, together with the amount of current which passed through a tangent galvanometer. The difficulties, however, in using a fine platinum wire with a moderate battery power were great. The wire would fuse before the measurements could be satisfactorily made. I then employed a strip of platinum foil $5^{mm.}$ wide, about $5^{cm.}$ long, and about $\cdot02^{mm.}$ in thickness. This was placed in a shunt circuit of a small Gramme machine, in order that if the strip should fuse the dynamo machine should not race. With the proper speed and a suitable adjustment of resistances the light from the platinum strip could be maintained very constant. The strip was placed in a long Ritchie photometer box, which was provided with two mirrors inclined according to the plan of Ritchie. One half of the photometer disc was illuminated by the incandescent strip, and the other half by a sperm candle. The electrical current was measured by a tangent galvanometer, of which the reduction factor was ·44 in the C.-G.-S. system. The difference of potential at the ends of the strip was measured by a Thomson quadrant electrometer, the deflections of which were compared with that of a Daniell cell, the electromotive force of which was approximately 1·09 volts. A Thomson voltmeter was also used. The indications of this instrument agreed with those of the electrometer. The following table gives the deflections of the instrument:—

Deflection of tan. galv. in deg.	Deflec. of electrometer in centimetres.	Remarks.
63	5·3	Light the colour of
61	4·9	a candle.
59	4·6	
57	4·3	
54·5	3·8	
53·75	3·4	Light very dull red.

One Daniell cell gave a deflection with the electrometer of $1\cdot3^{cm.}$ The resistance of the platinum strip when cold was ·2 of an ohm. It will be seen from the above results that the current varied approximately from 8 to 6 amperes (webers) with an electromotive force of from 3·8 to 2·6 volts, while the resistance varied from ·47 to ·44 of an ohm, the resistance when cold being ·2 of an ohm. The range of the indications of the electrical instruments was comparatively small, while the light varied enormously. It is evident that the chief difficulty of this method is in measuring a strong current with accuracy; for an increase in the current, represented by a fraction of a degree of the tangent galvanometer, will result in a very large increase in the light from the incandescent strip.

I next endeavoured to ascertain if a thermal junction enclosed in an Edison incandescent lamp at the centre of the carbon loop would be sensitive to changes in the heat radiation of the lamp. It is evident that, if this were the case, the carbon loop

* This arrangement was actually adopted by Herr A. Zettler, of No. 3, Zweibrüchenstrasse in this town.

† American *Academy of Arts and Sciences.*

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might be raised to the same point of incandescence in successive times, assuming that the thermal junction at this point of incandescence receives the same amount of radiant energy. Mr. Edison kindly provided me with a lamp in which one thermal junction of an alloy of iridium-platinum and platinum was inserted as the centre of carbon loops. The other junction was placed in ice and water. The thermo-electric force of this combination, however, was extremely feeble. The difficulty of inserting wires of other metals into glass prevented me from carrying this idea further. Instead of the thermal junction, a small loop of extremely fine platinum was placed at the centre of a carbon loop in an Edison lamp. This fine wire constituted a bolometer strip, and made one branch of a Wheatstone bridge, it being my intention to place a similar strip in another branch of the bridge, thus making a bolometer. The lamp was placed in a photometer box, and its light was compared with that of a candle as it was raised from a red glow to that of a light of 15 candle-power. At the same time the resistance of the fine platinum wire was measured by a Wheatstone bridge. The following table gives the results:—

Resist. of the Strip in ohms.	Dist. of Carbon Lamp from Photometer Disc.	Dist. of Candle from Photometer Disc.
	cm.	cm.
14·42	70	40
14·45	85	40
14·55	98	40
14·62	108	40

This method seems to be quite sensitive. The change in resistance is large when estimated by the number of ohms necessary to restore a balance to the bridge. It was noticed that at a certain point a comparatively small increase in heat radiations was accompanied by a large change in the amount of the light emitted.

This phenomenon had been noticed early by Dr. J. W. Draper. One Leclanché cell, with 5 ohms in the circuit, besides the resistance of the strip, was sufficient to raise the latter to a red heat, and precautions were then necessary to prevent a change of resistance from the heating effect of the battery employed with the Wheatstone bridge. Being desirous of ascertaining whether the resistance of the platinum wire changed after it had been heated to a red heat and had been allowed to cool, I arranged the resistance of the battery circuit outside the bridge, so that the wire could be raised to a red heat, and then, having quickly weakened the battery circuit, remeasured the resistance of the strip. No difference could be perceived in the resistance of the strip. This illustrated the fact discovered by Prof. Langley, that thin strips of metal arranged as bolometer strips give up heat very quickly.

The results of this experiment led me to think that a bolometer strip of definite surface could be placed at a fixed distance from a carbon loop of definite dimensions inside an exhausted glass vessel. The amount of radiation which the bolometer strip receives could be calculated, and we might base our standard of light upon the point of incandescence, which would give a definite radiation at a fixed distance. We could not distinguish by this method the energy produced by rays of definite refrangibility. It seems desirable, however, to substitute for the uncertain estimation of coloured lights by the eye an instrument which will measure the energy produced by the radiating source at a certain distance. Within certain limits I found that the bolometer strip would indicate an increase or decrease of the amount of radiant energy received, while the difference in the colour of the incandescent lamp made the observer at the photometer entirely uncertain of his measurements.

Owing to the difficulty of obtaining the proper apparatus for the prosecution of the study of this method, I then studied the question of the practicability of employing a thermopile to measure the amount of radiation from an incandescent strip of platinum at a fixed distance. Within a long photometer box was placed a thin brass vessel containing water. Steam was passed by means of a rubber hose into the water in this vessel, which was thus maintained at a constant temperature of about 94°C. The outside of the vessel was about 92°C. This was ascertained by making the side of the vessel constitute one metal of a thermal junction. Between this vessel and the platinum strip, which was made incandescent by a current of from eight to nine amperes (webers), was placed a thermopile. The face of the thermopile was thus exposed to the radiation from a given amount of heated surface at a constant temperature, while the other was exposed to the radiation of a given surface of platinum. The faces of the thermopile were provided with the customary cones, and a series of diaphragms of thick cardboard extended between the radiating surfaces of the vessel containing the heated water and the platinum strip. The thermopile was connected with a short coil galvanometer, and was moved until the galvanometer needle came to zero. This arrangement was extremely sensitive—a movement of a centimetre in the position of the faces of the pole being sufficient to drive the spot of light from the galvanometer mirror off the scale, corresponding to a movement of nearly fifty centimetre-scale divisions. There is no difficulty in effecting a balance as quickly as an ordinary photometric measurement is made. While one observer compares a candle or other source of light with the light from an incandescent strip of platinum, another could make the measurements with the thermopile, and could obtain the amount of energy radiated by the incandescent strip in terms of the constant source of heat. It is necessary to reverse the faces of the thermopile, or to place a second constant source of heat on the same side upon which the incandescent strip is placed. The following table indicates the character of the results:—

Deflec. of tan. galv.	Temp. of water.	Dist. of face and pole from water.	Dist. of face of pole from strips.	Remarks.
°	°C.	cm.	cm.	
57·5	95	26·5	49·5	Dull red.
56·5	95	28	48	
61	96	25·5	50·5	Bright yellow
62·5	96·5	24·5	51·5	„ „
62·5	96	23·0	53·	„ „
60·5	97	25·7	50·3	„ „
58·5	97·5	26·7	49·3	„ „
60	95	24·2	51·8	„ „
62·2	94	23·7	52·3	„ „

The reduction factor of the galvanometer was ·44 in the C.-G.-S. system. When the photometric indications were the same, the thermopile indicated a large change in the amount of heat received. Thus the heat indications within the range in which the experiments were taken were far more sensitive than the photometric indications.

It seems possible, therefore, to assume as a standard of light an incandescent strip which radiates a definite amount of energy, this energy being measured at a fixed distance which will best agree numerically with the absolute system of measures now universally adopted in heat and electricity. The method of Draper and Schwendler could be combined with the methods I have described above. For a practical standard, a carbon loop in an exhausted vessel raised to such a point of incandescence that it will radiate a definite amount of energy. This energy, being measured by a bolometer strip or the thermopile at a definite distance from the carbon loop, and also being measured by the formula $J H = C^2 R t$, would have a greater range than an incandescent strip of platinum placed in free air. The latter method, however, for the incandescence which produces a light similar in colour to that of a sperm candle, is extremely sensitive, and can be made, I think, more exact than present photometric tests. Both methods have the great advantage of substituting a measure of energy for a relative indication by the eye, which is not connected with any absolute measurement. These remarks apply to the question of a standard of light for practical purposes, which should also be scientific in so far that more refined scientific investigation can connect this standard at any time with more precise methods of measuring the exact amount of heat given by radiations of definite wave-lengths. By means of a "Rowland" concave grating, and with a bolometer strip, one can at present measure the energy of definite radiations. We can say that our scientific standards

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for light of definite colours shall be based upon the energy received upon a definite surface at definite points in the diffraction spectrum.

Jefferson Physical Laboratory, Harvard College.

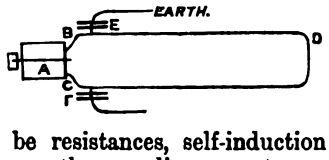
ON AN UNNOTICED DANGER IN CERTAIN APPARATUS FOR DISTRIBUTION OF ELECTRICITY.*

BY J. HOPKINSON, F.R.S.

Many plans have been proposed, and several have been to a greater or less extent practically used, for combining the advantage of economy arising from a high potential in the conductors which convey the electric current from the place where it is generated with the advantages of a low potential at the various points where the electricity is used. A low potential is necessary where the electricity is used; partly because the lamps, whether arc or incandescent, each require a low potential, and partly because a high potential may easily become dangerous to life. Amongst the plans which have been tried for locally transforming a supply of high potential to a lower and safer, the most promising is by the use of secondary generators or induction-coils. It has been proved that this method can be used with great economy of electric power and with convenience; under proper construction of the induction-coils it may also be perfectly safe. It is, however, easy and very natural so to construct them that they shall be good in all other respects but that of safety to life—that they shall introduce an unexpected risk to those using the supply.

In a distribution of electricity by secondary generators, an alternating current is led in succession through the primary coils of a series of induction-coils, one for each group or system of lamps. The lamps connect the two terminals of the secondary coil of the induction coils. It is easy to so construct the induction coils that the difference of potential between the terminals of the secondary coils may be any suitable number of volts, such as 50 or 100; whilst the potential of the primary circuit, as measured between the terminals of the dynamo machine, may be very great, *e.g.*, 2,000 or 3,000 volts. If the electro-magnetic action between the primary and secondary coils, on which the useful effect of the arrangement depends, were the only action, the supply would be perfectly safe to the user so long as apparatus with which he could not interfere was in proper order. But the electro-magnetic action is not the only one. Theoretically speaking, every induction coil is also a condenser, and the primary coil acts electro-statically as well as electro-magnetically upon the secondary coil. This electrostatic action may easily become dangerous if the secondary generator is so constructed that its electrostatic capacity, regarded as a condenser, is other than a very small quantity.

Imagine an alternate-current dynamo machine, A, its terminals, B, C, connected by a continuous conductor, B D C,



on which may be resistances, self-induction coils, secondary generators, or any other appliances; at any point is a condenser, E, one coating of which is connected to the conductor, or may indeed be part of it, the other is connected to earth through a resistance, R. Let K be the capacity of the condenser, V the potential at time t of the earth coating of the condenser, U the potential of the other coating, x the current in resistance R to the condenser from the earth, being taken as positive, and the earth potential as zero. We have

$$x = \frac{V}{R}, \quad K(U' - V') = 2$$

whence, since

$$U = A \sin 2\pi n t,$$

where A is a constant depending on the circumstances of the dynamo circuit as well as the electromotive force of the machine, and n is the reciprocal of the periodic time of the machine, we have

$$KR\dot{x} + x = 2\pi n KA \cos 2\pi n t,$$

$$x = \frac{2\pi n KA}{(KR2\pi n)^2 + 1}\{ - 2\pi n KR \sin 2\pi n t + \cos 2\pi n t\},$$

$$\text{mean square of } x = \frac{2\pi n K}{\sqrt{(KR2\pi n)^2 + 1}} . \text{mean square of A.}$$

Let us now consider the actual values likely to occur in practice. Let the condenser E be a secondary generator; let the resistance R be that of some person touching some part of the secondary circuit, and also making contact to earth with some other part of the body; n may be anything from 100 to 250, say 150; K will depend on the construction of the secondary generator—it may be as high as 0·3 microfarad or even more, but there would be no difficulty even in large instruments in keeping it down to one hundredth of this or less. The mean square of A will depend on the circumstances of other parts of the circuit; it might very easily be as great, or very nearly as great, as the mean difference of potential between the terminals of the machine if the primary circuit were to earth at C. Suppose, however, that the circuit B D C is symmetrical, that E is at one end, and that another person of the same resistance as the person at E is touching the secondary circuit of the secondary generator F at the other end of the circuit. In that case, if 2,400 be difference of potential of the machine, mean square of A will be 1,200; in which case we have, taking R as 2,000 ohms, mean

$$\text{square of } x = \frac{2\pi \times 150 \times 0{\cdot}3 \times 10^{-6}}{\sqrt{(2\pi \times 150 \times 0{\cdot}3 \times 10^{-6} \times 2000)^2 + 1}} \times 1200$$

$$= \text{about } 0{\cdot}3 \text{ ampere.}$$

Experiments are still wanting to show what current may be considered as certain to kill a man, but it is very doubtful whether any man could stand 0·3 ampere for a sensible length of time. It is probable that if the two persons both took firm hold of the secondary conductors of E and F, both would be killed. If the person at F be replaced by an accidental dead earth on the secondary circuit of F, the person at E would experience a greater current than 0·3 ampere.

It follows from the preceding consideration that secondary generators of large electrostatic capacity are essentially dangerous, even though the insulation of the primary circuit and of the primary coils from the secondary coils is perfect. The moral is—for the constructor, take care that the secondary generators have not a large electrostatic capacity, say not more than 0·03 microfarad, better less than $\frac{1}{100}$ microfarad; for the inspector, test the system for safety. The test is very easy. Place a secondary generator of greatest capacity at one end of the line and connect its secondary circuit to earth through any instrument suitable for measuring alternate currents under one ampere; put the other end of the primary to earth; the reading of the current-measuring instrument should not exceed such a current as it may be demonstrated a man can endure with safety.

* From the *Phil. Mag.*, Sept. 1885,

DR. ARON'S ELECTRICITY METER.

Herr F. Zacharias, who in his capacity as engineer to the Berliner Elektrische Beleuchtungs Actien Gesellschaft has frequently to experiment with and report on new electrical inventions, with a view to their being adopted by his company, has sent us an article for publication under the above heading. Although we have already described this meter (vide *Electrician* of January 10, 1885), we think a short translation of Herr Zacharias' remarks will be of interest to the reader, as they refer to the actual working of the instruments during the last few months. Without entering into any minute description we may recall to mind that Dr. Aron's meter is a pendulum clock, the rate of accelleration of which, in comparison to standard time, is exactly proportional to the strength of the current. The bulb of the pendulum is replaced by a cylindrical magnet, and below it is placed the coil through which the current flows. The direction of the current is such as to draw the magnet down, increasing, so to speak, the influence of gravity, and thus accellerating the clock. In order that the accelleration may be exactly proportional to the current, it is important to employ for the magnet steel of a certain

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hardness. The temporary magnetisation it receives from the current can be thus made to correspond to the second term in the equation for the time of oscillation throughout a wide range of current strength, which renders the instrument exceedingly accurate. The advantages of this meter over the chemical meter of Edison are obvious. In the latter the indications vary with the temperature, and the weighing of the plates requires the utmost care. It has also happened that the plates have been short-circuited by the deposit of zinc, and during the time the plates are dried and weighed the meter is out of action. All these disadvantages are overcome in Dr. Aron's meter. The reading does not interrupt the action of the instrument, and errors committed in single readings eliminate each other when added up to arrive at the total quantity of electricity passed during an extended period.

The Municipality of Berlin have, before finally adopting any form of meter, caused experiments to be made with the Edison and Aron meters. These were undertaken at the town gasworks under the direction of Herr Fröhlich, and although the results have not been published, it must be assumed that they were favourable to the Aron meter, as this instrument has been finally adopted.

One of Dr. Aron's meters, designed for a maximum current of 200 amperes, has been in use for some months in the electric light station in the Ausstellungs Park. In this instrument an acceleration of one hour corresponds to 1,356 ampere hours, or 2,260 lamp hours, each lamp hour being equivalent to a current of ·6 ampere flowing for one hour. With a current of about 100 amperes the clock is accelerated about 20 minutes in four to five hours. It will be evident that with such a large rate of advance any slight error in the clock itself or in the reading becomes quite insignificant. The following table, taken from the records of the above installation, will show the method of booking :—

1885.	Standard time.	Meter.	Total difference.	Last difference.	Ampere hours.	Lamp hours.	Value ·04 mark per lamp hour.
July 25.	4^{35}	10^{58}	6^{20}	1^{32}	2088	3480	$139^{\cdot 21}$
Aug. 1..	11^{43}	7^{38}	7^{52}				

For arc light installations working with a constant current a similar instrument is used registering volt-hours. It is suitable for a pressure not exceeding 2,000 volts. One hour accelleration corresponds to 41,022 volt hours, and if there are 25 arc lights in series the rate of advance in five hours is about ten minutes. The booking is similar to the example just given. For instance—

1885.	Standard time.	Meter.	Total difference.	Last difference.	Volt hours.	Lamp hours.	Value ·75 mark per lamp hour.
Aug. 20..	2^{28}	12^{45}	10^{17}	$0^{10\cdot 5}$	7179	156	116 mark
Aug. 21..	$10^{7\cdot 5}$	8^{38}	$10^{27\cdot 5}$				

These meters must be periodically wound up just as any ordinary clock. If, however, it is desired to have a self-winding clock, Dr. Aron adds to his meter a dry cell and an electro-magnetic apparatus which keeps the clock going without any attention whatever being required. The writer has lately seen such a clock which had been going for nine months without having been touched.

THE ELECTRIC LAUNCH "VOLTA."

On Monday, the 31st ult., the "Volta" was successfully launched at Greenwich Ferry, the "christening" ceremony being performed by Miss Stephens, daughter of the senior partner of the firm of Stephens, Smith, and Co., engineers, Millwall, who are the contractors for this new vessel. The hull of the "Volta" is of galvanised steel, and is 36ft. long, 7ft. beam, and 3ft. 6in. deep, built at Mr. Skelton's yard at Millwall; her draught, with a displacement of 5½ tons, is 26in. aft, and 20in. forward. There are several novel features worthy of notice in this boat. Two Reckenzaun motors, arranged in a line with the keel, and placed under the floor, are used for driving the screw propeller in a similar manner as the worm gear is driven in Mr. Reckenzaun's elecric tramcars. By sending the electric current through the motors with their circuits arranged in series or in parallel, or through one motor alone, various speeds and powers are obtained, without introducing artificial resistances, or varying the E.M.F. of the battery. Thus, 4, 7, or 12 horse-power, equivalent to 5, 9, and 15 indicated horse-power of a steam engine, are obtained on the screw shaft at will, with corresponding speeds of the boat. Seventy accumulators of the E.P.S. type furnish the current, which will propel the launch about 40 miles with one charge; these cells are placed at the bottom of the boat, under the floor, so low down as to ballast her in the most perfect manner, such as could not be attained by any steamboat.

There are two masts provided, and sails; the masts fit into sockets, and are speedily placed or removed; these sails have been supplied, in accordance with the specification, to economise the power, when requisite, for longer trips than allowed for in the accumulator.

Considerable interest was evinced by the crowd witnessing the launching ceremony, when the new vessel was towed up the river by another electric launch, both boats being well filled with invited parties. The "Volta" is to make a 40 mile trial trip down the Thames, to which many notabilities will be invited, and afterwards a voyage across the English Channal is contemplated.

THE UNITED TELEPHONE COMPANY (LIMITED).

We have been favoured with advance sheets of a long article on this company to appear in the *Weekly Bulletin*, from which we abstract the following information. Unfortunately, we must say most distinctly that we are not in accord with our contemporary as regards its conclusions. Our opinions about overhead wires, way-leaves, Government interference, &c., have so frequently and plainly been given that it is unnecessary to discuss these questions further at present. We may, however, find it necessary to criticise the statements of our contemporary *seriatim*, and reserve to ourselves the time and moment best suited for so doing :—

"The subscribed capital of the United Telephone Company is £500,000. The accounts are made up annually to April 30th, and submitted in July or August. The working of 1880-81 resulted in a net profit of £370, which was carried forward, but a distribution of 10s. per share was made in 1881 out of moneys received in payment for concessions granted by this company. For 1881-82 a dividend of 5 per cent. was paid; for 1882-83 6 per cent., for 1883-84 8 per cent., and for 1884-85 10 per cent. the accounts showing that 15 per cent. has been earned.

Subjoined is a comparative statement of the annual revenue compiled from the company's published audited accounts, which merits careful investigation.

For the undermentioned years, ended 30th April :—

Receipts :—	1881. £	1882. £	1883. £	1884. £	1885. £
Subscriptions and Rentals—					
London	13,346	21,313	43,935	62,537	70,189
Provincial	1,832	5,425	5,360	6,667	*Nil.**
Royalties	4,800	12,840	12,287	17,940	22,857
Dividends on Shares in Provincial Companies	...	1,835	2,506	4,688	9,680
Interest and Transfer Fees. .	666	1,211	738	512	274
Gross Revenue	20,644	42,624	64,826	92,344	103,000
Expenses and Depreciation written off :—					
London	19,140	15,662	32,294	40,991	46,408
Provincial	1,133	5,388	5,380	6,697	*Nil.**
Net Revenue	371	21,574	26,452	44,656	56,592
Subscribers to London Exchange	914	1,673	2,745	3,350	3,820
Private Lines—					
London District	186	366	576	715	835
Proportions of Subscriptions and Rentals carried forward to following year—					
London district	8,479	18,490	27,923	30,755	36,372

*Note.—The South of England and Western Counties and South Wales Telephone Companies purchased the remaining provincial businesses, so that Receipts and Expenses under that head now disappear.

The Company owns

Shares.	Worth. £	s.	d.
50,000 of £1 Lanc. and Cheshire at 26s. ...	*65,000	0	0
45,000 of £5 National at 55s.	*123,750	0	0
7,500 of £5 Northern District at 40s.....	15,000	0	0
87,500 of £1 Tel. of Ireland at 5s.	*21,875	0	0
95,750 of £1 South of England at say 5s. ...	23,437	0	0
160,000 of £1 West of England at say 5s. ...	40,000	0	0
	£289,062	0	0

Those marked * pay dividends.

We repeat, therefore, that the United Telephone Company owns £653,750 nominal capital—with a present selling value of say £300,000—in subsidiary companies.

As an instance of progress in the use of the telephone in the town of

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Southampton (a comparatively small city) 26 sets of instruments were bought some two months ago, whilst a fresh order for a further 26 has been received within the last few days. This shows a telephone exchange for this small place of 50 upwards, as a commencement. The same procedure is going on with the other companies, and telephone exchanges have now been opened at the following cities, all of which belong either to the United Telephone Company (Limited), or to its children :—

Wigan	Aberdeen	Bolton	Liverpool
Chorley	Dundee	Warrington	Birkenhead
Denbigh	Forfar	Todmorden	Chester
Rhyl	Belfast	Altrincham and Bowdon	Southport
Wrexham	Bradford	Rochdale	St. Helens
Bangor	Leeds	Heywood	Widnes
Holyhead	Huddersfield	Bury	Barrow
Welshpool	Dewsbury	Oldham	Windermere
Newtown	Halifax	Dublin	Ulverston
Flint	Wakefield	Sunderland	Preston
Carnarvon	Birmingham	Newcastle	Lancaster
Llandudno	Wolverhampton	North Shields	Blackpool
St. Asaph	Walsall	South Shields	Fleetwood
Glasgow	Wednesbury	Bristol	Blackburn
Greenock	Dudley	Brighton	Darwen
Paisley	Brierley Hill	Norwich	Accrington
Dumbarton	Stourbridge	Stockport	Burnley
Edinburgh	Nottingham		Colne and Nelson
Kirkcaldy	Manchester		

As instancing the ideas of those living in distant parts, we might here say that the River Plate Telephone Companies have at the present moment, in the City of Buenos Ayres alone, got the comparatively enormous quantity of 2,500 subscribers to its system. In London there are about 4,500 only. Can words say more ?

In America the telephone has been utilised as far as Chicago to New York, some 1,000 miles ; but for some reason (probably cost) this wire has been discontinued for the moment, and the longest distance now open for public communication is between New York and Boston, a distance of 300 miles ; and here it is found to work perfectly.

The sums paid for the rights of any towns in U.S. of 20,000 or 30,000 inhabitants are very large, and increase year by year, as it is felt that the system is what we may term a brand new one as regards past generations, and people there are prepared to discount the future.

Now we will take one American city, viz., Indianapolis, with a population of 74,000. In this town there are no less than 940 subscribers. Chicago has 3,800 subscribers with a population of under half a million, and the same proportion seems to hold good with every city in the Union.

We repeat, that London with a five-million population has barely 4,500 subscribers. If it held its proportion as against Chicago it would have 40,000.

The great difficulty in England seems to be the way-leaves, viz., the getting permission to carry the wires over the different houses, but we have reason to hope that in the next Session of Parliament a short Bill will be brought in which shall render it compulsory on the owners of house property to permit wires to be carried over the roofs. A committee of the House of Commons has reported that this course must be pursued.

Once let this be done, and telephony will receive a great impetus. But greater still than this will be the start the company will receive when the Government, changing its "dog in the manger" theory, will permit the United Telephone Company to carry its wires along the present existing posts, which posts have of course been the outcome of many years, whether before or after the Government took over the telegraphs.

Now from Richmond alone, the United Telephone Company is constantly getting many grumbles, and no wonder, as it seems ludicrous that this town, only a few miles from London, should not be connected with an exchange.

We are informed that the Government would require a payment of some £10 per wire per mile per annum for this service, and this alone would mean a big sum. For this reason : to connect with Richmond the company would require, say, ten wires, which should leave the City, and gradually reducing its number, eventually end at the town we speak of. It would require, say, ten wires as far as Kensington. One wire should go to a Kensington exchange. This would leave nine wires, one of which should go, say, to Fulham to work an exchange there, leaving eight ; one to Putney, leaving seven ; one to Barnes, leaving six ; one to Mortlake, leaving five ; and so on until one wire would enter the Richmond exchange. In other words, the ten little niggers—nursery tale—would be utilised in the way of telephony.

If the Government would only give the company power to Richmond, watch what would inevitably follow, within a year or two. We should have exchanges at Twickenham, Isleworth, Surbiton, Kingston, every station, in fact every town within a suburban radius of say 20, 30, or 40 miles, and the facilities with which business could then be carried on can be easily imagined. At the present moment the longest telephone wire in existence in England is that worked by Mr. Colman between Norwich and London.

This wire is 120 miles in length, and constant conversations can be carried on between the two points as easily as if the speakers were in one room.

We are perfectly prepared to admit that telephony, as worked in this country, is a monopoly, and is run by a ring. We believe this will never be altered, and aver that with the capital subscribed already by the public, competition—at least serious competition—can never come into dangerous force. What is to prevent other powerful monopolists at the present time from being destroyed ? Only one thing—King Capital —which has got most good things entirely in its clutches, and there it means to keep them.

The United Telephone Company has too much money and too strong backers to fear innovations, and anything serious would at once, as before, be nipped in the bud. The "Mechanical Telephone," the shares of which were allotted lately, is no invention at all, being as old as the hills. It is useless in the same idea as an electrical telephone, and can be made by any one who likes to try an experiment.

When the "United Telephone" patents fall in it will be found that, irrespective of new improved patents, which will give fresh life to the concern, the company will have such a command of exchanges, way-leaves, &c., that it will own an absolute monopoly, and it will be useless for any attempt at competition. A monopoly such as this would be practically unassailable, and shareholders need have no fear of their rights ever being combated.

But not only to our mind have shareholders got all the facts we have printed to look forward to, but we suggest that ultimately the Government will be compelled to buy up and take over the entire system of telephony. We cannot believe that any other course can be pursued, when, as now, the telegraphs have ceased to be individual property. The saving to the country at large would be very great, as the poles would carry both systems of wires. The only extra cost would be the wires themselves—a comparative bagatelle. Telephony must in the majority of cases completely upset the value of the telegraph. There are rumoured discoveries of vibrating instruments which will record conversations by printing. Up to the present the idea is embryonic, but one day it will come to the fore, and then, what will the Government do ?

It *must* purchase existing companies out and utilise its own systems, which by that time will emphatically embrace the telephone."

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Sept. 2.		Business Done Week Ending Sept. 2. Highest.	Lowest.
Anglo-American	30,	31	32	31
Do. Preferred	51½,	52½	53½	51½
Do. Deferred	8,	9	9	8½
Brazilian Submarine	11,	11½	11 3-16	11
Cuba	12,	12½	12 5-16	12 3-16
Do. Preference	18,	19	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	12,	12½	12	—
Direct United States Cable	8¾,	9¼	9¼	9
Eastern Telegraph	11⅜,	11⅝	11 13-16	11⅝
Do. 6 per Cent. Preference	13½,	13⅞	13⅞	13½
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12⅜,	12⅝	12 15-16	12 11-16
German Union	9½,	9⅝	—	—
Globe Telegraph and Trust	7,	7½	7 3-16	7
Do. Preference	12⅜,	13½	13½	12⅝
Great Northern	13⅞,	14½	14 1-16	14
Indo-European	30½,	31½	—	—
Reuter's	7½,	8	—	—
Submarine	185	195	—	—
West India and Panama	¾,	1	—	—
Do. 1st Preference	8½,	8¾	8½	8⅝
Western Brazilian	6,	6½	—	—
Western Union 7 per Cent. 1st Mortgage	120,	124	—	—
Do. 6 per Cent. Sterling Bonds	100,	102	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅛,	¼	—	—
Oriental	⅛,	¼	—	—
United Telephone	11½,	12	11⅝	11½

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	—	—
Do. (fully paid)	2⅞,	3½	—	—
Hammond Light (£3 15s. paid)	1-16 3-16		—	—
Swan	½,	¾	½	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	36½,	37½	37½	36⅝
India-Rubber, Gutta Percha, and Telegraph Works	23½,	24½	24½	24

TRAFFIC RECEIPTS FOR AUGUST, 1885.

Companies.	Aug., 1885.	Aug., 1884.	Increase.	Decrease.
Brazilian Submarine	11,896	—	—	—
Cuba Submarine	2,200	2,515	—	315
Direct Spanish Telegraph	1,276	1,190	86	—
Western and Brazilian	7,153	—	—	—

The International Inventions Exhibition.—The Executive Council of this Exhibition have completed arrangements with the whole of the Railway Companies of the United Kingdom whereby parties numbering 25 and upwards can from the present time and until the close of the Exhibition, obtain at greatly reduced rates through tickets, combining the journey to London, carriage over the Underground Railways, passage through the South Kensington Subway, and admission to the Exhibition, and back. Application for these facilities should be made to any Station Master in the Country.—[ADVT.]

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NOTES.

NOTICE OF REPAIR.—The cable of the Paris and New York Telegraph Company has been repaired.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended the 4th inst. amounted to £2,951.

LIGHTHOUSE ILLUMINANTS.—The report of the Committee on Lighthouse Illuminants, of which we have already published a full accouut, was issued on Saturday as a Parliamentary Blue-book.

THE TELEGRAPH AND THE TURKISH ISLANDS.—Telegraph offices have been opened in the Turkish Islands of Lemnos and Tenedos. The rates to Lemnos and Tenedos are the same as those at Scio.

THUNDERSTORM.—On the 4th inst. a thunderstorm of great violence was experienced throughout the whole of the Grantham district. The lightning was very vivid, and the rain fell in torrents, doing considerable damage.

LIGHTNING.—On August 20, during a storm, lightning entered a dynamo in the electric-light plant of Erie, Pa., destroying it, and resulting in the extinguishing of all the electric lamps in the streets of the city.

CONTRACT.—We are informed that the contract for putting in the necessary wire for an incandescent light installation in the new State House at Indianapolis has been obtained by Messrs. W. S. Glover and Co., of Detroit, Mich.

THE EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of August amounted to £41,987, and to £39,463 for the corresponding period of 1884; increase, £2,524.

NEW ELECTRIC WORKS.—It is said that the Edison Company are about to establish new electric lighting works at Dijon. Operations have already been commenced, and arrangements will be made for an installation of 500 lamps.

THE ELECTRIC LIGHT IN TORONTO.—The Fire and Gas Committee of Toronto Council has been unable to make a contract with the Consumers' Gas Company or with the Electric Light Company, and will ask for new proposals for lighting the streets.

TRANSMISSION OF FORCE AT TERGNIER.—A new installation for the transmission of force has recently been inaugurated at Tergnier, in the Magasins Généraux, to actuate, at a distance of 180 metres, an apparatus which serves to elevate the molasses, &c.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 4th Sept. were £2,254, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE ELECTRIC LIGHT IN PLYMOUTH.—On the occasion of the Architectural Exhibition at Plymouth, the drill hall was lighted at night by electricity. The installation, on the Thomson-Houston system, was put in by Messrs. Laing, Wharton and Down.

THE GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this company for August, 1885, amounted to £24,000; from 1st January to 31st August, 1885, £192,040. For the corresponding months of 1884 they amounted to £182,680; in 1883 to £168,400.

SEARCH LIGHTS AT TORPEDO STATIONS.—Experiments were made at the torpedo station of Newport, R.I., on the night of August 18, with a movable 15,000 candle-power electric search light for use at sea. It was found to work perfectly, minute objects being discernible at great distances.

AN UNFORTUNATE ACCIDENT.—At Atlantic City, N.J., a popular health resort, the blowing out of a cylinder head of the engine driving the electric lighting machinery left the promenade in darkness one evening recently, and produced a little panic, in which two persons were injured.

THE ELECTRIC LIGHT IN NEWFOUNDLAND.—Advices from America state that the Thomson-Houston Company have contracted for 90 arc lights, together with a number of incandescents, for St. John's, N.F. The contract also includes dynamos, engines, and everything necessary for a complete installation.

THE ELECTRIC LIGHT IN FRANCE.—On the occasion of the coming fête at Châtillon-sur-Seine, on the 13th inst., the picturesque promenade of that town will be lighted, at the request of the municipality, by ten arc lamps.—The work of installing the electric light in the Opera House, Paris, is rapidly approaching completion.

THE DELIVERY OF TELEGRAMS.—The United States Supreme Court has just decided that in the case of a telegram addressed to any particular individual the company may, in his absence, cause it to be delivered to his wife. There are times, however, when the most reasonable of beings would object to this course.

THE FRENCH TELEGRAPHS.—The new subterranean line of telegraph connecting Paris with Marseilles has recently been completed. By order of the Minister of Posts and Telegraphs new offices are to be opened in the following districts:—Saint-jean-Brévelay (Morbihan), Cébazat (Puy-de-Dôme), Fyé (Sarthe), and Verneuil (Seine et Oise).

PERSONAL.—The command of the submarine mining battalion of Royal Engineers at Chatham is to be at once taken over by Colonel V. G. Clayton, late commanding Royal Engineers, Jamaica, who will succeed Colonel G. W. Stockley. The latter officer, who is now on leave from Ceylon, has held the temporary command of the battalion.

THE LIGHTING OF DUNDALK.—Despite the recent relapse in the lighting of the town of Dundalk, a constant reader assures us that it will in a few months hold the proud distinction of being the first town in Ireland, and one of the first in the United Kingdom, to be lighted entirely by electricity. We trust our correspondent is correct in his premises.

THE LATEST FROM PARIS!—UN COMBLE.—Le dernier...de la saison:—

Le comble de l'amour électrique?
Un *électro-aimant!!!*
Nous nommerons le coupable, si on nous y force.

l'Electricien.

THE ELECTRIC LIGHT AT HASTINGS.—The electric light came in for sundry strictures on the occasion of a recent meeting of the shareholders of the Hastings Pier Company. Like a good many more penny wise and pound foolish people, the shareholders of that company would rather pocket an extra twopence than encourage the only thing that makes night on the pier at Hastings enjoyable.

ELECTRICITY AND BLASTING.—A mass of granite, estimated to weigh at least 500,000 tons, was displaced recently on the line of the Iron Mountain Railroad, Missouri, by a single blast. A shaft 65ft. deep was sunk, with lateral chambers, in which

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five tons of powder were stored. After the shaft had been nearly filled to the top, an electric spark from a battery half a mile distant fired the magazine, with the result indicated.

"THE HEART OF THE ENGLISH TELEGRAPHS."—*Correction.* In our article under this heading last week the pneumatic tube system at the Central Telegraph Station was spoken of as being worked on the double sluice valve system of Messrs. Siemens and Halske; and that the local or house tubes had the form of valve designed by Mr. Latimer Clark. We are now requested to state that both forms of valve actually in use were designed by Mr. J. W. Willmot, an officer of the Engineer-in-Chief's Department, G.P.O.

ROYAL COLLEGE OF SCIENCE FOR IRELAND.—Particulars will be found in our advertisement columns of the scientific and technical education, classed broadly under the heads of Chemical Manufactures, Mining and Engineering, supplied at this college. There are four Royal scholarships, each of the value of £50 yearly, with free education, including laboratory instruction. Two of these become vacant each year, and are open to students who have been a year in the college. In addition to this a "Diploma of Associate" is granted at the end of the three years' course.

MORE RELICS.—Mr. Hall, an American electrician, has, says a transatlantic contemporary, just added to his collection of electrical curiosities three new pieces of apparatus. One of these is a battery made and used by Benjamin Franklin in his experiments with electricity. This battery is one of the first used by Franklin, and is an interesting relic. The others are very valuable also, one being the first electro-magnet made by Professor Henry, peculiar in shape and mounting. The other is an old electrical machine made by Nairne, of London. Mr. Hall also has in his possession the model of the first electrical railway, of which he claims to be the inventor.

TRIAL OF AN ELECTRIC LOG.—The Indian troopship "Crocodile" made a two hours' full-power trial of her machinery on the morning of the 9th inst., in charge of two officers of the Portsmouth Steam Reserve, Mr. Mayson representing the factory department. The draught of the ship forward was 18½ft. and 23ft. aft. A mean pressure of 60lb. of steam was maintained in the boilers, and the vacuum in the condensers was also good. The average revolutions per minute was 54. The mean speed realised was 13½ knots. The trial was perfectly satisfactory. During the run Mr. Brunel made a trial of a new electric log for determining the speed of the ship at any given moment. It worked very well for some time, but was eventually carried away by the strain thrown upon the electric connections,

UNDERGROUND WIRES IN BROOKLYN, U.S.A.—There are 5,508 poles, 3,856 1-5 miles of wire and 6·21 miles of cable in Brooklyn. The Electrical Subway Commissioners are daily occupied in the examination of plans submitted for placing the wires underground. They are considering a system by which the wires on certain streets shall be put underground and kept entirely out of sight. The wires will be introduced into buildings under the sidewalks. Another plan under consideration is to bring up the wires at certain intervals and string them along on poles, from which they will connect with subscribers' stations. The poles would be placed a long distance apart, so that the number would be greatly reduced. In districts which are sparsely settled it appears to be the sense of the commission not to put the wires under the surface.

SOMETHING WRONG.—The imagination present in the office of the *Milwaukee Sentinel* is of a pretty high order. The following is the latest production of that ever truthful paper:—"To deter boys from climbing the telephone poles at Fond du Lac the plan of attaching wire to the spikes and connecting them with a battery was conceived, and it worked to perfection. The first day no less than 200 boys attempted to climb the pole, but immediately received such a shock that they retreated in dismay. Later, however, a farmer drove up to the pole and hitched his horses. One of the animals unsuspectingly caught hold of the spike, and immediately there was a start and a jump and the hitching strap snapped and away went the team. The farmer suffered the fracture of three ribs in attempting to stop the runaways, one or more women were run over, and the waggon smashed to atoms."

THE EDISON-SWAN LAMP.—Arrangements are now in progress for the removal of this company's lamp factory from Newcastle-on-Tyne to a new and extensive factory at Ponder's End, in the neighbourhood of London. This step has, we are informed, been necessitated by the large increase of the company's business. Of the 15,558 incandescent lamps lighted at night at the International Inventions Exhibition the Edison-Swan Company have supplied 12,298; in addition to which they have 3,310 lamps in the "Swan' and "Edison and Swan" stalls, so that there are altogether 15,608 of this company's incandescent lamps at the Inventions Exhibition. This number, when compared with the exhibit of 1,200 lamps by the Edison and Swan Companies at the Crystal Palace Exhibition in 1882, serves as a fair indication of the very real progress of incandescent electric lighting during the past three years.

THE EARL'S COURT ACCIDENT.—In the opinion of the *Daily News*, which comments on the inquiry into the recent fatal collision on the Metropolitan District Railway, it is scarcely satisfactory to find that such a serious accident can take place and nobody be to blame. It adds:—"It appears that a connecting rod broke, so that the signal did not answer to the signalman's lever. But there is an electrical apparatus which tells the occupant of the signal box how the signal stands. Why did this fail? The explanation offered at the inquest is that the sudden jerk given by the breaking of the rod caused the electric indicator to lose its hold, and so to testify falsely. It is, perhaps, inevitable that the best machinery should now and then fail; but this case is a new and rather striking illustration of the small things on which the safety of a train and its living load may sometimes depend."

MORE GAIETIES AT BERLIN.—On the evening of the 7th inst. the hospitality of which the members of the Telegraph Conference have been the lavish objects in Berlin culminated in an entertainment given them by the Municipality in the spacious halls of the Rathhaus—an entertainment which was a mixture of a *conversazione*, a classical concert, a theatrical performance, and a supper. The dramatic part of the entertainment consisted in an allegory entitled "Electra," specially written for the occasion by Herr von Wildenbruch, the only poet who in recent years has been thought worthy to be honoured with the Schiller prize. The *dramatis personæ* of the piece were: Mother Nature, Man (Der Mensch), Electra, the Demon of Gunpowder (a most terrific sprite), and Peace (a white robed and palm-branch bearing youth, crowned with a coronet of electric lamps)—and all these parts were played by histrionic "stars" from the Schauspielhaus.

THE TELEGRAPH AT ORMISTON.—The following letter appeared in a recent issue of the *Scotsman*, from a resident of Ormiston:—"A few months ago a movement was inaugurated in Ormiston, East Lothian, to requisition the postal authorities to establish a telegraph and money order office in the village.

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The necessary guarantee having been raised by subscription, the poles were erected and wires attached to the existing system at Tranent, and the public were informed that operations would begin on 1st August. The money order office duly started operations, but as yet there are no signs of the telegraph making a start, which is a source of great inconvenience to the inhabitants of Ormiston and the surrounding parishes. As one of the guarantors, I am very anxious to know when the public will have the facility of using the telegraph; and as no information can be obtained from the village postmaster, I would feel obliged if you would allow me this mode of eliciting an answer."

THE BRUSH PATENT IN AMERICA.—It was recently decided in the U.S. Circuit Court, District of Connecticut, in the case of Brush *et al. v.* the Naugatuck Railroad Company *et al*, that the plea of the Naugatuck Company, licensees under the Weston patent, which set up privity of estate with their licensor, the United States Electric Lighting Company, the real defendants in the suit of Brush *v.* Condit, involving the Brush and Weston patents, and which set up the judgment in said suit (that the Brush patent was anticipated by the Hager patent) as a bar to the present suit, be overruled, for the reason that the Brush and Weston patents were for different inventions, although the Weston lamp cannot be made without using the Brush clamp, and the judgment in the former suit (which threw the claimed combination open to the public) was not an adjudication of the validity or scope of the Weston patent, so as to make a case of privity of estate in behalf of licensees under it. The plea of William D. Bishop, which set up non-infringement, was overruled under Sharpe *v.* Reissner.

THE ELECTRIC LIGHTING OF TREBERG.—The little town of Tréberg, long known for its manufacture of clocks, contains about 2,500 inhabitants. It is situated at the bottom of the Gutach Valley, some 2,300 feet below the sea level, and is surrounded on all sides by hills of some 1,000 feet in height. The Gutach, it will be remembered, forms, not far from there, a celebrated waterfall, one of the finest in Germany. In the neighbourhood of the waterfall there are a number of factories, but, strange to say, no effort or scarcely any effort has been made to utilise the great flow of water. Up till now the streets of the town have been miserably lighted by petroleum, but, in order to satisfy the numerous visitors to so picturesque and so salubrious a locality, it has been decided to adopt electricity as the illuminant. The installation has been put down by Messrs. Weil and Neumann, of Freiburg, who have used their own plant for the purpose. It includes 12 arc lamps of 1,500 candle-power (of which three are spare), supplied with current by a dynamo driven from a turbine. The total cost has been £744. That of maintenance, &c., is about 50 per cent. greater than with the ancient method, but more than ten times the amount of light is given.

AN AUTOGRAPHIC TELEGRAPH.—The *Scientific American* contains an account of an autographic or copying telegraph instrument, the invention of Mr. Sylvester P. Denison, which is being introduced by the New York Auto-Telegraph Company, of 47, Broadway, New York. With the aid of these instruments, suitably connected by wires, it is possible for any one to send *fac simile* copies of messages from place to place. The message is written upon a narrow strip of bronzed paper, which is placed over a roller at one side of the instrument; the movement of a lever sends an electric current through the machine, out over the line, and through a second similar machine. The current moves a stylus, which vibrates rapidly over and in contact with the bronzed strip; each time the point in its passage across the paper meets the ink of the writing the current is broken, when a second current passes over the line to the other instrument and through a like stylus, moving back and forth across a strip of paper so prepared as to be discoloured whenever the current passes through it. As the two styluses move absolutely in unison, the exact location of each particle of ink that causes a break in the current is reproduced, by electrolysis, on the chemically-prepared strip at the second instrument. The machine requires no attention beyond the switching of the current from the transmitting to the receiving side, as may be required.

THE CITY AND GUILDS OF LONDON INSTITUTE.—The programme of technological examinations for the session 1885-86 has just been issued. In reviewing a work on this kind or in quoting from it the difficulty is not what to put in but what to leave out, so interesting are its contents. The subjects of more general interest to our readers will be, however, those relating to telegraphy, electric lighting and transmission of power, and electrical instrument making. These are very comprehensive in their character, and speak well for the course of instruction given by the Institute. We are acquainted with a few electricians of mature age who would be rather puzzled by some of the questions in the Honours Grade Section of each of the subjects we have mentioned. The following prizes will be given in each subject, provided the merits of the candidates justify the examiners in awarding them :—

Honours grade	1st Prize	£5 and a Silver Medal.	
	2nd „	£5 „	Bronze „
Ordinary grade	1st Prize	£3 and a Silver Medal.	
	2nd „	£3 „	Bronze „
	3rd „	£2 „	„ „
	4th „	£1 „	„ „
	5th „	a Bronze Medal.	

Candidates who have obtained a First Class Certificate in honours may be re-examined in the same grade, provided they have not already obtained a prize in that grade; but candidates who are so re-examined and fail to obtain a prize will not be entitled to a second certificate, and their names will not be entered on the Pass List. W. H. Preece, F.R.S., and Professor A. Fleming, D.Sc., are the examiners in electrical engineering. Two better men could not well be found.

A NEW ASSOCIATION.—We have much pleasure in announcing that an old students' dinner, in connection with the City and Guilds of London Technical College, Finsbury, will take place on Thursday, October 1st, at the Manchester Hotel, Aldersgate-street, commencing at 6:45 p.m. Professor S. P. Thompson, D.Sc., Principal of the College, has consented to be present. After dinner it is intended to form an Old Students' Association. A provisional committee, consisting of Messrs. R. E. Baker, H. N. Lawrence, H. Marks, A. D. Raine, A. W. Slater, A. C. Webb, and S. Williamson has prepared a set of rules to be submitted to the meeting. The following is a draft scheme of the proposed association :—Its object is, primarily, to promote social intercourse among, and forward as far as possible the advancement of, its members; also to encourage in its members a continued interest in the welfare of the college. All old students (day and evening) are eligible until January 1st, 1886, to become members on paying the subscription, but after that date all applicants must be proposed at one meeting and balloted for at the next. The meetings will be monthly during the winter, some devoted to reading and discussing papers by members on scientific subjects, others to concerts or similar amusements. One silver medal will be given from the funds of the association annually to the member whose paper (read at one of the meetings during the year) shall be selected by the commitee as possessing the greatest merit. The objects of this association com-

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mend themselves to us. We wish its promoters every success.

RAPID PHOTOGRAPHY.—An invention that is creating some interest is the application of electricity to making photographic exposures in quick succession and at regular intervals of time or distance; also making that succession of exposures from different points of view at the same corresponding intervals of time or distance. The apparatus, we are informed, includes three groups of twelve cameras each, for photographing from three points—the side, the front, and the rear. The three groups do their work simultaneously. First the three number one cameras act, then three number twos, and so on until the three number twelves have operated. All this gives thirty-six different views at twelve intervals of time. One round movement of an animal, as a flap up and down of a bird's wing, is shown in twelve different phases, each phase being potographed from three different points. Leclanché batteries of thirty-six cells each are used in connection with each group. The cable connecting the battery with the camera contained thirteen wires, one being a return wire and the others being connected with twelve electro-magnets that are immediately above the twelve cameras. The apparatus can photograph a movement occupying the one five-thousandth part of a second of time. The calculations of the time of the movement of an animal as a whole, or of the motion of any one part of the body in comparison with the motion of any other part, are made by means of the "background," a large square of canvas stretched on a wooden frame, and divided by cords into forty-eight squares. Each of the forty-eight squares is sub-divided by thinner cords into 100 spaces, each two inches square. If the animal to be photographed is white or light in colour the canvas is black and the cords white. If the colour of the animal is dark the canvas is white-washed and the cords black. The background is photographed with the animal, and the mathematical calculations are made upon the positions of the photographed phases of motion along the little squares.

UNIVERSITY COLLEGE, BRISTOL.—The next session of the college will begin on October 6th. Lectures and classes are held every day and evening throughout the session. In the Chemical Department lectures and classes are given in all branches of theoretical chemistry, and instruction in practical chemistry is given daily in the chemical laboratory. A special practical class for clothworkers and dyers is carried on by correspondence, and excursions to some of the mines, manufactories, and chemical works of the neighbourhood are occasionally made. The department of experimental physics includes various courses of lectures arranged progressively, and practical instruction is given in the physical and electrical laboratory. The department of engineering and the constructive professions is designed to afford a thorough scientific education to students intending to become engineers, or to enter any of the allied professions, and to supplement the ordinary professional training by systematic technical teaching. This department includes courses specially arranged for students intending to become civil, mechanical, or electrical engineers, surveyors, or architects. Those who attend the mechanical engineering course enter engineering works during the six summer months, and in accordance with this scheme various manufacturing engineers in the neighbourhood have consented to receive students of the college into their offices and workshops as articled pupils. The engineering laboratory has recently been provided with a powerful testing machine, and instruction in the use of tools is given in the workshop. Special courses in surveying have been arranged, and excursions for field practice are frequently made. The departments of geology, biology, and zoology include various courses of lectures in all the branches of these subjects, together with laboratory instruction. In the botanical department practical instruction is given by means of the Botanical Gardens, which contain upwards of 1,000 specimens. Courses of lectures and classes are given in mathematics, political economy, logic, moral philosophy, modern history, English literature, Greek, Latin, Hebrew, French and German. Medical education is provided by the Bristol Medical School, which is affiliated to the college. Several scholarships are tenable at the college.

A REMARKABLE ATMOSPHERIC PHENOMENON.—A description of a remarkable atmospheric phenomenon, which was noticed on August 6, has been communicated to the Swiss local press by Prof. Calladon, of Geneva. Until after five o'clock p.m. the sky had been clear and calm all over the valley of the Leman, but half an hour later, although the atmosphere above the lake and neighbouring mountain remained remarkably still, vapours were seen at a great height (evidently produced by a strong and warm south west wind in the upper air) advancing rapidly towards the north east, and taking the undulatory forms which characterise clouds strongly charged with electricity. Three hours afterwards the sky bore a decidedly stormy aspect. The thick cloud masses oscillated wildly, albeit their general movement was still from south west to north east. After nine o'clock these clouds, drawing away, rendered visible the bank of cirrus which stretched above them. The cirrus was phosphorescent, and looked as if lighted up by a bright moon. On the north western horizon the sky along all the chain of the Jura was obscured by thick clouds that from time to time were illuminated by flashes of lightning. It was the same over Mont Galene, above which the lightning played every few minutes. A long black cloud stretching from the Dôle to the Galene presented on each side a broad phosphorescent border, and about a quarter-past nine there became suddenly visible in that part of the cloud nearest the Jura a luminous centre whence escaped two or three phosphorescent rays pointing towards the south-west. This phenomenon lasted some twenty minutes, and was sufficiently striking to be remarked by many observers. From a quarter-past nine to eleven o'clock, moreover, the south-western extremity of Mont Galene was illuminated by a phosphorescent light so intense that its rays were visible from every part of the horizon. The general appearance of this south-west section of the Galene resembled that which is presented by the city of Geneva in the thick weather when the mists of evening are lighted up by the gas of the streets. Some rare instances are on record of forests of resinous trees becoming phosphorescent in stormy weather, but the distance from Geneva was too great to enable observers to determine whether the light resulted from the phosphorescence of the fir trees which cover the sides of the Galene or from that of other parts of the mountain. The Central Meteorological Bureau at Zurich publishes about eight o'clock every morning daily accounts of the general condition of the atmosphere throughout Europe, and special reports from twelve stations in Switzerland at eight o'clock a.m. and one o'clock p.m. These reports are received at Geneva on the following day, and those on August 5 and 6 show that on the dates in question there took place a complete change in the atmospheric equilibrium of western Europe, and that the high pressures which for several weeks previously had prevailed over England and the Channel suddenly ceased and gave place to warm, vapour-charged winds from the south west.

A NOVEL ADVERTISEMENT.—Mr. Edgar Bruce, of the Prince's Theatre, was apparently not aware until recently, remarks a contemporary, that street advertising is subject to

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the control of the Commissioners of Police, or he would have taken care to obtain the requisite permission before startling Piccadilly with his latest novelty. About a fortnight ago the manager of the Prince's hit upon the odd notion of sending out sandwich-men armed with poles, to the ends of which were fixed electric lanterns containing an advertisement of his house; but the bearers were stopped by the police. In order that the matter might be tested, one of them—George Johnson—was brought up at Marlborough-street. Mr. Wontner was instructed to appear for the defendant, and urged that his client had no knowledge that he was acting against the police regulations. Of course the plea of ignorance could not absolve Mr. Bruce from responsibility, and the magistrate had no option but to inflict a nominal penalty, which he did to the amount of a shilling and costs. One of the arguments used by the police was that the electric burners were liable to frighten horses. It was very pertinently suggested by Mr. Wontner that as the electric light was the light of the future, the sooner horses became accustomed to it the better. Mr. Bruce may yet be able to secure the approval of the commissioner for his ingenious advertisement. With the long dark nights coming on an accession of moving electric lights in the streets would be a distinct boon in many of our present ill-lighted thoroughfares. Mr. Bruce has subsequently written the following letter to the morning papers:—"From published reports of the result of the summons heard at Marlborough-street on Saturday last respecting the electric lighted balloon advertisements of the Prince's Theatre, it might be thought that my men had carried through crowded thoroughfares a number of powerful arc lights to advertise the 'Great Pink Pearl.' I am unwilling that it should be thought I am capable of announcing my entertainments at a risk to the public safety. May I therefore ask you to kindly state the following facts respecting the balloons which apparently have so offended the police? They are constructed of a light wire framework covered in silk, bearing the words, 'Prince's Theatre, "Great Pink Pearl," every evening at nine.' They measure 45in. in circumference, and the light inside is equal only to 5 candle-power, and this is considerably reduced by the colour of the silk, an ordinary pink. The balloons were carried, by the aid of canes, at a height of 10ft. above the pavement, and yet the witnessing constable objected to these dim and elevated lights, his reason being that they frightened horses. My men, when cautioned by the police, were walking quietly along Piccadilly pavement on their way to Kensington with a two-fold object in view, to advertise my theatre, and to add—in a small way, truly—(oh, sarcastic Mr. Bruce!) to the street lighting, which is but indifferent in the neighbourhood of the Inventions Exhibition. By the magistrate's decision it is evident that the police have power to forbid or allow these balloons to be carried in the streets. I am therefore petitioning the commissioners for the necessary permission, which, I am convinced, will be granted me when the harmless nature of the instrument is shown to them. Meanwhile, I am utilising my balloons as a stationary after-dark advertisement outside my theatre only." We see no earthly reason why a 5-candle incandescent light should be considered dangerous, or likely to frighten anything but a supporter of gas, if confined to the pavements. Mr. Bruce's idea is a good one, and if he thought fit to extend his philanthropy from the thoroughfares in the neighbourhood of the Exhibition to the section of the Exhibition itself which contains the electrical exhibits, he would be regarded as a benefactor by others than the general public.

THE TELEGRAPH CONFERENCE.—Advices from Berlin dated the 7th instant state that the sittings of the commission for tariffs and administrative rules on Thursday, Friday, and Saturday gave rise to much discussion on subjects of considerable importance. Proposals respecting the compilation of an official code by the Bureau International in Berne, the mode of counting and charging for words used in code messages, and the reimbursement of the cost of messages sent for the purpose of ascertaining whether a code message has been correctly telegraphed were discussed. The commission, however, decided that no official code should be drawn up, but that the present rule, which permits the use of any word to be found in standard dictionaries of the eight admitted languages, with its legitimate inflections, should be retained; also that the rule allowing fifteen letters in a code word for European messages should be abolished, and the number of letters reduced to ten, but that, as in extra-European code messages, the words might be taken out of any or all of the eight languages, instead of, as at present, out of one language only. Further, that the return of charges for rectifying errors in plain or code language in unregistered European messages should no longer be allowed, but that as regarded extra-European telegrams each State should be at liberty to refund such money if it desired to. There appears to be some probability that the rates between England and Russia and Spain and some other countries will be reduced, and also the rates between England and India and Australia; in the case of India probably by 7d. per word, and in that of Australia by about 2s. 6d. Later reports give the following interesting rules with respect to a prospective system of international telephony, which have been approved in committee, and will in all probability be accepted by the full Conference:—"1. The Administrations of the contracting States may establish, as required, international telephonic communication, either by laying special wires, or by devoting to this service wires already existing. 2. In default of special arrangements between the said Administrations, these wires shall be conducted into a central telephonic office of each, and thence connected either with the telephonic office provided for public use, or with private houses, offices, workshops, &c. 3. The Administrations shall agree upon the choice of materials, and the details of the service, They shall fix in common the rate to be paid for each telephonic line. 4. The unit adopted for the collection of rates and duration of communications is a conversation of five minutes' length. 5. The use of the telephone shall be allotted in the order of applications. The same correspondents shall not be allowed more than two consecutive conversations of five minutes each, except when no other application shall be made, before or during those conversations." The following rules with respect to money orders have also been approved in committee:—"1. Post Office orders may be sent by telegraph between offices which agree to adopt that mode of transmission. They are then to be called telegraphic orders. 2. Telegraphic orders are to be charged for and treated as ordinary private telegrams. They may, on the same conditions as apply to the latter, be submitted to the formalities of urgency, repetition, acknowledgment, and delivery by post or messenger. Besides the prescribed portion hereinafter mentioned, they may contain a private message from the sender to the receiver. 3. Telegraphic orders are to be addressed by the office which has received the money and address to the office which is to pay them. 4. Partial repetition is to be obligatory—namely, of names and amounts. 5. The office receiving orders shall take such measures as may seem advisable for delivery of the order to the person entitled to it, and for the collection of the cost of carriage beyond the lines." It is expected that the Conference will be able to dispose of all its work in a day or two, and to separate next week. Several representatives of private companies have already left.

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THE BRITISH ASSOCIATION MEETING.

(FROM OUR SPECIAL CORRESPONDENT.)

ABERDEEN, Wednesday.

The fifty-fifth meeting of the British Association, now being held at Aberden, is likely to be fairly representative so far as mere numbers are concerned, but whether the addresses and papers will be scientifically valuable the future must judge. The business of the Association commenced to-day with the meeting of the General Committee, at which the report of the Council for 1884-5 was discussed and adopted, and one or two formal matters disposed of. The report mentions that Professor Bonney, the secretary, had at the commencement of the year stated his intention of not seeking re-election at the present meeting, and paid a tribute to his powers of organisation and tact, which proved so useful at Montreal. The Council have nominated Mr. A. T. Atchison, M.A., who for some years past has rendered most efficient assistance as one of the secretaries of Section G, to the office of secretary, vacated by Professor Bonney.

Reference was made in the report to the successful meeting at Montreal, and the stimulus it gave to the energy and life of the Association. Certain resolutions referred by the General Committee to the Council for consideration, and action if desirable, were mentioned. That concerning the tides of the Gulf of St. Lawrence and adjoining coast, their systematic observation and tabulation, and the establishment of observing stations had formed the subject of a communication from the Council to the Canadian Government. Another communication to the Canadian Government related to the urgent necessity of encouraging investigation with respect to the physical characters, languages, social industries, and artistic condition of the native tribes. The time was not thought opportune for action relating to the resolution urging the importance of the employment of the harmonic analysis in the reduction of Admiralty tidal observations.

The most interesting paragraph in the report was probably that relating to the feasibility of instituting a scheme for promoting an International Scientific Congress, to meet at intervals in different countries. This subject is to come on for discussion at the general meeting on Monday. With the report some informal correspondence between Professor Bonney on the one side and Dr. C. S. Minot on the other side was distributed. Professor Bonney pointed out the difficulties in the way of such a general congress, while Dr. Minot examined and commented upon these difficulties, giving also a clear and succinct summary of the opinion in America. It may be well to give an extract from Dr. C. S. Minot's original letter. He says :—

As regards four points there is, as far as ascertained, a general unanimity of opinion in this country :—

1. That it is desirable that the organisation should be initiated through the co-operation of Great Britain and North America, and that other countries be invited to join when the plans are somewhat advanced.
2. That London is the most desirable place for the first meeting.
3. Only persons of acknowledged scientific standing to be admitted to membership.
4. The meetings to be held not oftener than once in three years.

From the consultations held, I have derived the following suggestions as to the plan of organisation :—

1. To have a committee in each country, to whom shall be confided the duty of selecting scientific men of their country to be delegates to the Congress ; these committees to have considerable discretion. Where there is a National Association, that body might be invited to appoint the committee for its own nation. (Our American committee has already, under the general powers given it, authority to do this.)
2. These committees (but after the organisation of the Congress, the delegates) to elect an allotted number of representatives who shall form the permanent governing council of the Congress and administer its affairs. The members of the council to hold office from the time of their election until the next meeting of the Congress.
3. The council to appoint a committee for each meeting, with full powers to make all arrangements for that meeting. This committee to include the members of the council who are representatives of the country in which the meeting is to be held ; to have power to add to its numbers, and to nominate officers for the meeting.
4. Each delegate to pay an assessment towards meeting the expenses of the Association, and not to be admitted to the meeting until the payment has been made.
5. The Congress to divide into sections to meet separately. The committee on the meeting to have discretionary power to invite distinguished persons to deliver addresses before the sections, or to participate in the meeting.
6. Investigating committees shall be appointed by the council, either upon their own initiative or upon the approval of a recommendation from a section. It shall be the policy to encourage such work as requires international co-operation, and to induce Governments to join in and support such work under the general supervision of the Congress.
7. The place of meeting to be fixed by the Council ; but two successive meetings shall not be held in the same country.
8. French, German, and English to be the official languages.

In place of the retiring members of the Council, the following gentlemen are recommended for election :—W. T. Blandford, Esq., F.R.S. ; W. Crookes, Esq., F.R.S. ; J. B. Martin, Esq., F.S.S. ; Prof. H. M'Leva, F.R.S. ; and W. T. Thiselton-Dyer, Esq., C.M.G., F.R.S.

The report of the treasurer was adopted.

What may be called the real business of the meeting commenced with the delivery of the Presidential Address in the evening, at the Music Hall. This address, which is given elsewhere, deals with general questions rather than with special technical subjects, and will perhaps for that reason commend itself all the more to the general body politic.

(BY TELEGRAPH.)

ABERDEEN, Thursday Evening.

To-day, in the Mathematical Section, Prof. Crystal's address was devoted to advocating the greater diffusion of scientific teaching throughout the whole kingdom. He maintained that under the system which had grown up in recent years there was an excess of examining over teaching-power, and that, in fact, we were overrun with examinations ; trying to reap before we have sown. As a practical remedy he suggested, for one thing, the opening up of existing scientific societies to every comer, with, if necessary, an inner court of the Temple of Learning as a place for titular immortals. For example, the British Association itself might continue and extend its work of reporting the progress of special branches of science ; and he thought good would arise if the prophets of the science world deliver courses of lectures at intervals at different places, so that teachers and others might hear and gain knowledge at first hand.

Several papers interesting to electricians were afterwards read in the section, viz :—Lord Rayleigh, "On the Thermodynamic Efficiency of Thermopiles" ; Mr. T. Gray, "On the Measurement of the Intensity of the Horizontal Component of the Earth's Magnetic Field" ; Prof. Smith, "On Atmospheric Electricity ;" Prof. Parmor, "On Molecular Distances in Galvanic Polarisation ;" Dr. Home, "On the Employment of Mance's Method of Eliminating Polarisation for Testing the Resistance of the Human Body." Mr. Bottomley read three papers, viz., "New Experiments in Contact Electricity ;" "A Specimen of Almost Unmagnetisable Steel ;" and "Cooling of Wires in Air and Vacuum."

In the Chemical Section Prof. Ramsay read a paper, entitled "Observations on the Action of a Grove's Gas Battery."

On Tuesday next there will be a special discussion in this section on Electrolysis. Monday will be devoted to electrical papers, when Mr. Preece will read one on "Experiments as to the Strength of Round Timber," and Mr. Shoolbred another on "The Lighting of the Forth Bridge."

Prof. Adams's evening lecture on "Electric Light and Atmospheric Absorption" will be delivered to morrow (Friday) evening.

Up to last night 2,031 tickets had been sold, thus securing the success of the Aberdeen meeting.

ARCS IN AN INCANDESCENT LAMP CIRCUIT.—At a recent meeting of the National Electric Light Association in New York, Dr. Moses expressed his opinion on the subject of working arc lamps on incandescent circuits. He thought the usual kind of differential arc lamp to be unfit for a system that required, in order to be efficient, a lamp whose regulation was a direct function of the current. The lamp should respond with great rapidity to every variation in its condition, and for such purpose an electro-magnet at the point of saturation was most useful on account of its great sensibility.

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HISTORY OF THE INCANDESCENT LAMP.—II.

Almost contemporaneously with the labours of De Changy in Europe towards the construction of a serviceable incandescent lamp, vigorous efforts were being made in the New World towards the development of the same idea. J. W. Starr, from Cincinnati, applied himself thoroughly to the study of incandescent lamps, and had made experiments in platinum as well as in carbon. Starr, being a man of very limited means, would hardly have been in a position to carry through satisfactory experiments entailing so much time and expense had he not found in Peabody a generous patron and an enthusiastic promoter of his plans.

Starr came to England with King to take up the business part of the combination, and it was King's first object to win over the scientific circles to Starr's idea, and to present to the public an effectual demonstration of it. To this end he had a magnificent chandelier coustructed with 26 arms, on which, by electric lights, were symbolically represented the existing 26 States of the North American Republic. The result was fully successful; an enormous throng witnessed with amazement the novel and magnificent display, Faraday being present at the interesting experiment, and in flattering terms acquainted his American *confrères* with his satisfaction at the results obtained.

After the death of Starr, King came into his property, and hastened to have Starr's invention patented under his own name. The patent was published on the 4th November, 1845, and described as *a piece of carbon heated to incandescence in an exhausted receiver*, or a platinum wire similarly heated in the open air. This patent (No. 10,919) already contained all the essential principles of the carbon incandescent lamps now in use, viz.:—(1) The incandescent carbon must be as thin as possible, this being an anticipation of the carbon thread employed in most of the incandescent lamp systems of the present day. Here, too, may be found the fundamental principles of all carbon incandescent lamps ever patented, and an indication of the acumen shown by Starr in the definition of the principle of construction of an incandescent lamp. (2) The carbon must be attached to a platinum wire sealed into the glass. (3) The length and resistance of this carbon conductor must be made proportionate to the electromotive force employed. (4) The carbon must be heated to incandescence in a vacuum as perfect as possible. A sketch of King's carbon incandescent lamp can be seen in Fig. 1.

In a recent number of *Nature** may be read the following interesting letter, relating to the discoveries of De Changy and Starr and King, from Mr. Mattieu Williams, a contemporary of Starr:—

"In the 'Notes.' of *Nature*, in Vol. XXVII., p. 209, M. de Changy is described as 'the first electrician who attempted to manufacture incandescent lamps *in vacuo* about twenty years ago.' This invention and its successful practical application (irrespective of cost) was made by a young American, Mr. Starr, and patented by King in 1845. A short stick of gas retort carbon was used, and the vacuum obtained by connecting one end of this with a wire sealed through the top of a barometer tube blown out at the upper part, and the other end with a wire dipping into the mercury. The tube was about 36in. long, and thus the enlarged upper portion became a torrecellian vacuum when the tube was filled and inverted. I had a share of one-eighth in the venture, assisted in making the apparatus and some of the experiments, and after the death of Mr. Starr all the apparatus was assigned to me. I showed this light (in the original lamp) publicly many times at the Midland Institute, Birmingham, and on two occasions in the town hall, all of them more than twenty years ago. The light was far more brilliant and the carbon stick more durable than the flimsy threads of the incandescent lamps now in use. It was abandoned solely on account of the cost of supplying the power. As a steady, reliable, and beautiful light its success was complete. In a contribution to the 'History of Electric Lighting,' published in the *Jonrnal of Science*, November 5, 1879, and reprinted lately in my 'Science in Short Chapters,' may be found further particulars concerning this invention and its inventor."

Without wishing in the smallest degree to depreciate the services of Williams or Starr, we still hope that we have satisfactorily established by the above-mentioned authenticated dates the fact that De Changy was already at work at the construction of incandescent lamps before the appearance of Starr and his invention. As to the credit of the discovery of the incandescent lamp, if this be the place for the discussion of a pure invention, neither Starr nor De Changy can lay claim to it, for the conception of the principle of the incandescent lamp, as well as the first impulse towards its practical application, is due to Professor Jobard as long ago as 1838.

In 1845 the first platinum lamp also made its appearance, when Mr. E. Staite, on the occasion of a lecture in the Sunderland Athenæum, showed in operation the incandescent lamp represented in Fig. 2. The incandescent material was a platinum-iridium wire, held in position by two small upright brass pillars in a wooden stand.

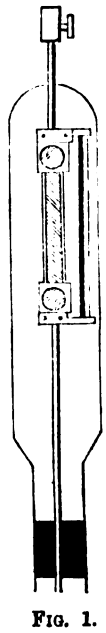

FIG. 1.

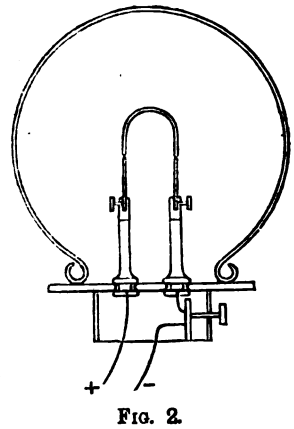

FIG. 2.

A year later Staite, in partnership with Greener, patented a lamp strikingly resembling King's, in which the carbon had been purified with nitric acid.

Three years after the patent of Greener and Staite the employment of iridium as incandescent substance was suggested in a patent taken out by Petrie. This idea so far commended itself as to be entertained by other electricians after him, but the high price of iridium, owing to its excessive rarity, precluded any practical application of it on economical grounds.

Ten years after the patenting of King's lamp in 1855 De Changy resumed, after a long interval, his investigations and experiments, pursuing them with redoubled energy. He made his researches at the same time in two directions. Without abandoning the carbon principle he applied himself to the construction of a system in which platinum appeared as incandescent substance, hoping with this metal to obtain much sooner a result which, if less perfect, would still be reasonably successful. But when he saw that in order to prevent fusion of the platinum wire the electrical current must be allowed to vary only between very narrow limits, he recognised the paramount necessity of constructing a current-regulator, which he patented in 1858.

It was intended that lamps provided with such a current-regulator should be applied to various purposes, some of them of considerable interest, as, for example, the lighting of mines, submarine lamps for fishing, small floating lights, and finally for nautical telegraphs,* in which, by means of a variety of

*This letter is a correct copy of Mr. Williams's communication to *Nature* of Jan. 11th, 1883.—[Ed. *E.*]

* This idea has been recently developed by an Austrian naval officer, named Sellner, who had his apparatus for the purpose constructed by Czeija and Nissl in Vienna, and by the firm of Saulter, Lemmonnier, and Co., in Paris.

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combinations produced by a keyboard, illuminated signals were to be sent from the masthead of a ship. The platinum employed in these incandescent lamps was subjected to a special process. De Changy first raised the metal to a moderate red heat, and then allowed it to rise gradually to the temperature which it had afterwards to stand continuously—a process the practical importance of which was some twenty years later recognised and acted on by Edison.

It may not prove uninteresting to the reader to learn what prejudice was still entertained at that time by the Brussels Academy of Sciences against all commercial industries, and what an illiberal and one-sided view was then taken in learned circles of the profession of scientific investigators. Thus, when De Changy, a short time after obtaining his patent, submitted the results of his investigations to the Academy of Sciences, the latter sent a commission to institute an examination of the subject.

Deprez, who was a member of this commission, asked Herr Jobard by letter for a detailed description of the apparatus connected with De Changy's invention, and of all the technical preliminaries. Herr Jobard was naturally compelled to reply that it was impossible for him to give so full an explanation, for such a publication might have a prejudicial effect on the patent just obtained. On receiving this reply, M. Deprez announced that since M. De Changy wished to make his invention the basis of a remunerative industry, he had no claim to the title of a scientific man, and the Academy must therefore decline any further concern with his work.

This answer was naturally not calculated to encourage De Changy towards further researches. The result was that he abandoned his investigations in connection with incandescent lamps.

During the next fifteen years little worth mentioning occurred. Now and then there was another appearance of a "latest and most perfect" discovery, destined, as a rule, to vanish without leaving any lasting trace of its existence. It was in 1873 that the development of this lamp took a turn for the better, when a Russian *savant*, M. Lodyguine, succeeded in inventing an incandescent lamp, for which the St. Petersburg Academy of Science awarded him the first prize. The chief principles of his lamp may be thus summarised.

In an exhausted receiver are fitted small sticks of carbon, fitted at their extremities into two cubes of the same material. But since the lamp was badly sealed and the exhaustion was therefore deceptive, Lodyguine thought it sufficient after a single exhaustion of his receiver merely to close it hermetically, and so prevent any renewal of the oxygen when it had once been consumed. But this lamp, in spite of the improvements of M. Rosloff, of St. Petersburg, could not vindicate its existence in a practical sphere, and so shared the fate of its predecessors. The same may be said of Roun's and Bouligine's carbon incandescent lamps, the first of which was patented in the year 1875, the second in the year 1876. All these lamps suffered from the same drawback, that the carbon in process of time crumbled and finally broke in the middle, while the renewal of the useless carbon was rendered very troublesome by the fact that the lamp was sealed up.

After all these fruitless essays, a man at last appeared who had already won a name in the different branches of practical electricity, and who now was driven by his restless zeal after new triumphs to seek for fresh laurels in the sphere of incandescent lamps. This man was Edison.

In 1878 Edison made an extended tour to the Rocky Mountains in the company of a distinguished American phycisist, who matured his resolution to attack the question of electrical illumination.

He provided his laboratory with the necessary apparatus for the study of the problem. Edison began his experiments with arc lamps, but soon renounced them to try his fortune in the path trodden by so many predecessors.

Like De Changy, Edison imagined that he could construct a lamp more easily and quickly with metal than with carbon, and it remained to definitely ascertain what metal was most suitable for the end in view.

Most of the experimenters in electricity suffered from lack of sufficient pecuniary means, which tended to paralyse them and prevent them from following out their expensive experiments, for the majority of these scientific men lived in very limited financial circumstances, and had not all the good fortune to obtain the assistance of a Peabody in their undertakings. Edison's case was quite different; his industry had enriched him with several remunerative inventions, and we cannot, therefore, be surprised that the Electric Light Company called into being by him placed unlimited confidence in his inventive genius, and grudged no expense necessary to enable their manager to obtain the end he had set before him.

The following anecdote is interesting as bearing eloquent testimony to Edison's strength of will, often rising to actual stubbornness, and giving an instance of the colossal wealth at his disposal:—When Edison, in the search for a suitable material for his incandescent lamps, sent his assistants to all parts of the compass, his attention was drawn by one of them to the properties of the metal thorium as having a very high temperature of fusion. Edison immediately applied by letter to one of the most eminent mineralogists of the United States requesting him to send him a small quantity of this exceedingly rare metal. The *savant* replied with some Yankee sarcasm that it would afford him infinite pleasure to be able to put a few hundredweights of the required metal at the disposal of the eminent electrician, but this would be attended with great difficulty, as it would be impossible to obtain even half an ounce of it in the whole territory of the United States.

What was Edison's next move? He sent for one of his cleverest assistants, and informed him that in a gold mine of the Northern States, beneath a mass of valueless flint, some monarite crystals, from which thorium is obtained, had been unexpectedly discovered. Then he gave him a letter of credit to a very large amount, and said to him "Start at once, and bring me in as short a time as possible one hundred pounds of monarite." Three days later twenty miners were at work in the mine in question under the direction of the young assistant, who paid his workmen liberally, and allowed them besides all the gold brought to light, seeking only for the monarite himself. A few weeks later he returned to Menlo Park with the hundred pounds of monarite required. Edison began his experiments on the same day, and pursued them uninterruptedly till he was able to send the cynical *savant* several pounds of that metal, of which the latter had asserted that not half an ounce could be found in all America. This interesting account sufficiently proves with what a command of resources, and on what an extensive scale, the eminent American inventor pursued his investigations and experiments. The thorium so adventurously obtained did not fulfil Edison's expectations, and he found himself, therefore, compelled to return at last to De Changy's idea, and to fall back on platinum as the incandescent material for his lamps. He soon succeeded in constructing a platinum incandescent lamp which, as before mentioned, more nearly fulfilled the requirements of practical use than any produced by his numerous predecessors. Scarcely had the news of this so far satisfactory result reached the shareholders of the Electric Light Company, when they put in motion all the machinery of American assertion to sing the praises of the new lamp as an epoch making event.

The fickle spirit of speculation grasped eagerly at the opportunity offered, and capital coming down at the universal cry that the days of gas-lighting were numbered, the prices of electric light shares rose to the highest point, while a regular panic attacked the holders of gas stock.

But the heyday of the electric light shareholders was but short-lived. When it came to bringing the incandescent lamps so elaborately inaugurated to the crucial test of practical employment, it soon appeared how fast and loose the American press had been playing with the too credulous public. Though Edison's lamp was comparatively the most successful hitherto produced in that line, no idea could be entertained of any general adoption of it for practical purposes, and the new industry declined before it could be truly said to have made a regular stand.

For several years, even long before Edison's labours on the construction of an incandescent lamp, an English electrician, J. W. Swan, had been working hard to produce a lamp in which his constant aim was to obtain his object with carbon.

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In 1845, when Mr. Staite delivered his lecture in the Sunderland Athenæum, among his audience was Mr. J. W. Swan, whose attention was then first directed to the electric light. Soon after Swan began to experiment with the object of developing to a more perfect degree the principle previously established by King, that the incandescent carbon in the electric lamp must be as thin as possible.

CORRESPONDENCE.

TREATMENT OF SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I must ask your permission to say a few words more on the subject on which I addressed you last week, after reading Mr. Bernard Drake's letter, in order to show that I do not advise any course adverse to the experience of the E.P.S. Company.

My method of charging the cells is as scientific as it is possible to make it with practical considerations. Every ampere-hour which goes to the house is checked on a Ferranti meter.

The charging is done at the rate of 30 amperes, and if it becomes more or less, the means exist of making the current return to the normal. The readings are checked every half hour; or more often I chalked down on a suitably ruled black board. When the charging ampere hours equal the meter readings the process is stopped, and in general the the usual phenomena which are taken to indicate "fully charged" are observable in the cells. It will thus be seen that the cells are always kept up to the mark.

At this time of year an evening takes out approximately 80 ampere hours, and in two nights about 160 ampere hours; hence, say a 5½ hours' charge every other day puts back what is taken out. My cells are supposed to hold 530 ampere hours available, but I have never run them so low, and therefore cannot speak on this point.

I find by this process the positive plates whiten as the complete charge approaches, and they regain their colour later, as described in my letter.

I regard the disconnecting of cells containing liquid a most dangerous process, and I have seen many accidents arise from this cause, but fortunately no harm was ever done to any one, more by good luck than otherwise. The waste which arises at any time from short-circuiting a cell through a resistance is not worth talking of. Say every cell requires the process once each year (this is a fair average) for two hours each. This is equivalent to a two hours' run of 30 amperes (the general charging rate), or in coal, say a waste of ½cwt., worth 6d. per annum, to secure the good condition of the accumulator. This is even a high value.

However, the main point is, do the positive plates whiten (or sulphate (?)) or not by overcharging? Chemically speaking, I think they ought to do so, and practically I find that there is the tendency.

I further believe that this state of things would not exist if the plates could be sent out wet from the factory directly after "forming," instead of allowing them to dry; and many may not know that when the E.P.S. plates are removed from the acid they dry very rapidly, becoming so hot that one can scarcely touch them. I fully believe that many experiments conducted away from the factory would probably differ from these causes.

In conclusion, I must beg my readers not to suppose that I am against the use of E.P.S. cells, for my results have been very favourable. But to find out the truth in science has always been my aim, and for this end we must experiment for good or for bad.

If my results and suggestions are bad, prove them so under like conditions, and I shall be the first to renew the experiments to find where the fault existed.—Yours, &c.,

Sept. 7, 1885. DAVID SALOMONS.

A NEW TESTING INSTRUMENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Notwithstanding your note annexed to Mr. M. Volk's letter in your last issue, I imagine that his little instrument would prove useful. I made a similar contrivance three years ago, and have used it ever since. Before using I had only to allow the card to swing freely, and if it pointed to the north the magnetism was not reversed. I invariably found it correct. As wires were often fixed to roofs, I lettered both sides of the compass card, so that it could be used either above or below wire. It was often not easy to twist heavy or fixed-down wires into the magnetic meridian, so I added a little directing magnet, which could be slipped out when necessary. A narrow U-shaped copper strip slipped on the spring tight over the glass front and back, and as the ends projected I could use the whole as a galvanometer on an emergency. It was the most useful little tool I had, and might be made from 1s. to 2s. 6d. according to finish.—Yours, &c.,

JNO. M. M. MUNRO.

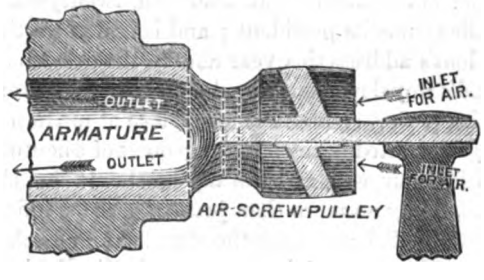
136, Bothwell-street, Glasgow, 5th September, 1885.

NEW PULLEY FOR DRIVING DYNAMO MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Perhaps the following may be interesting to your readers:—

I propose the use of a new pulley for driving dynamo machines, which at the same time serves to ventilate the armature, as follows:



The screw inside the pulley must be of such a shape as to give the best results for ventilation.

Can you kindly give me some information relating to the manufacture of carbon rods for electric light; as to the addresses of makers of the hydraulic and milling machinery; and about the process of manufacture?—Yours, &c.,

Slikkerveer, 8th Sept., 1885. WILLEM SMIT.

[We have no doubt that some of our readers will supply the required information.—ED. *E.*]

THE LIFE OF INCANDESCENT LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your article on the Law Courts installation there is a slight error in line 6 from bottom. Instead of "Grundy and Ready's holder" (*vide The Electrician*, p. 182, July 17), it should be, "Grundy's holder" (*vide The Electrician*, March 28th, 1885).—Yours, &c.,

A. GRUNDY,

Hazells, Gravesend, Sept. 8, 1885. Electrician R.C.J.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I beg to draw your attention to a slight error in your last week's issue, page 315. I am in conjunction with Mr. Grundy in the patent telescopic pendant only, and not in the holder, as stated.—Yours, &c., J. W. READY.

Law Courts, Strand, 7th Sept.

Answer to Correspondent.—Volt: The word "pressure" is very frequently used to denote E.M.F. or potential.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE BRITISH ASSOCIATION AT ABERDEEN.

The visit which members of the British Association will pay to Balmoral to-morrow, by invitation of the Queen, is a fitting though perhaps an unpremeditated tribute to the memory of Her Majesty's illustrious consort. On the occasion of the Association's last gathering at Aberdeen, twenty-six years ago, Prince Albert was its president; and it is natural that both in the president's address this year and in the gracious invitation to Scotland's Royal residence we should detect some reminiscence of him who, perhaps more than any prince of modern times, was genuinely interested in the encouragement of scientific pursuits. Sir Lyon Playfair was, as naturally he should be, eloquent on this theme, doing no more than justice, perhaps indeed less, to the debt which Science owes the statesman and scholar whose influence on the cause of higher education in England did not cease with his life, and whose hopes and practical schemes are being realised within a comparatively short time after his death.

It is, of course, to be expected that the president for the present year should be dissatisfied; there would be an end of presidents and presidential addresses if we had achieved all that we anticipate, and had satisfied all our desires. But we have only to look at the programme of the British Association's meeting in 1859 and compare it with that for 1885 to see not only the wonderful progress that has been made in adding to our store of exact knowledge, but also in widely extending the means for diffusing this knowledge. The subjects are not merely startlingly novel as compared with those of a generation ago, but it is plain that they appeal to a wider audience; that, whether abstruse or simple, they are so treated as to reach the world outside the charmed circle of the Association; and that, moreover, the lay press treats them with a respectful attention which would have been thought impossible, and by most scientists of that day even undesirable. The late Prince Consort, however, held opinions which, though common enough now, were unfamiliar then, expressing the conviction "that the State will recognise in science one of its elements of strength and prosperity, to foster which the clearest dictates of self-interest demand."

With this pregnant text the presidential address on Wednesday was chiefly occupied, the subject being the relations of science to the public weal. Such, at least, was Dr. Playfair's own account of the address. We should rather describe it as an appeal of science for State encouragement. In this he was no doubt following in the Prince's footsteps; but it may be questioned whether the Royal Patron would have pursued them in the same direction as far as his follower would seem to recommend. It is one thing for the State to foster and encourage science; it may be quite another thing to convert science into a State Establishment, which is apparently what the president is driving at. The fate of Establishments generally is not encouraging, certainly not north of the Tweed; and neither in the interests of science nor in those of its votaries will thoughtful men confidently recommend the reversion of the theological mantle to the shoulders of science.

The inevitable tendency of State departments is to run in a specified groove, and to treat as heretical and schismatic any independent departure from the track in which its subsidy is earned. For science to voluntarily bind itself in this fashion, or anything akin to it, seems to us incredible, and altogether inexpedient. The endowment of science by certain States, if the examples cited by Dr. Playfair are cases of that kind, have been of too recent date to afford proof of their wisdom. The magnificent expenditure on the University of Strasburg by Germany is as much a political act as an educational project. The reservation by the United States of 150,000,000 acres of national lands for the promotion of scientific education only awakens the reflection that the science of the States is fortunate in belonging to a country that has millions of acres to reserve for any useful purpose whatever. We decline to look upon these or any other examples of the kind as telling to England's discredit. They are the outcome of local circumstances or national peculiarities. We are second to no country in the thoroughness and soundness of our scientific reputation, and we very much doubt whether an endowment of fabulous acres would better us, or will enable any other nation to beat us.

But as regards the diffusion of scientific knowledge Dr. Playfair is on safer ground, though even here he fails to give a sufficient reason for artificially forcing the operation. The State can do only what the people desire it shall do, or at all events consent to its doing. Too frequently the State is spoken of as something distinct from and independent of the people. Dr. Playfair even talks of the people of this country being anxious for scientific or technical knowledge. The statistics furnished by the science classes are evidence of diffusion, but not of a general craving for it. The fact that popular constituencies elect scientific professors would count for something if we were sure that the science counted for anything with the electors. Twelve working class constituencies, it appears, have invited Sir Lyon Playfair himself to sit for them in Parliament. The scientific significance of that interesting fact would be plainer if this "humble representative of science," to use his own words, were not a very ardent and far from humble representative of politics. If scientists are wanted, there ought to be no lack of candidates. It is no disparagement of Dr. Playfair to say that eleven other men not less eminent in science can be found if these working class constituents will have them. But we suspect that, unless the scientist has countless acres to dispose of, as they have in America, the answer of the populace will be, as it assuredly would be in the States if endowment of science meant taxation, like the cry of the French revolutionists, "The Republic has no need of *savants*." In popular estimation "the value of science is measured by its application to the useful purposes of life." Dr. Playfair deprecates this low estimate of its value; but it must be confessed he does little to alter that impression, for the whole address is one long assertion of the material advantages accruing to the nation that will give itself up to the study and application of science.

Of course, Dr. Playfair has a higher conception of the province of science than this. He betrays it in many passages devoted to the science of the ancients, and in the enthusiasm with

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which he speaks of the famous dead who have devoted their lives to the study for its own sake. But in seeking to obtain a recognised position for modern scientists, which formerly they did not seek, and a State subsistence which they never asked for and rarely accepted, he is addressing unconsciously, and with the instincts of a politician, the populace who look only for the useful, and who see it only in the tangible. The relation of science to the public weal, or, in other words, the material advantages of a closer relationship between science and the State, is therefore necessarily the shape which the president's address has assumed. It is a confession that to appeal to higher motives would have been in vain; and it is also a plain indication of what we said at the outset, namely, that an association of scientists nowadays addresses itself to the non-scientific world hardly less than to its own members. We shall rejoice if this year's meeting in any way helps to convince the English public of the advantages to be derived from a diffusion of scientific knowledge; but it is not to be expected that the habits and genius of a nation will be suddenly transformed by State patronage. Dr. Playfair laments that Scotland is singularly deficient in respect to scientific instruction. Yet the Scotch, with the poorest endowments, are the best educated people of the three kingdoms. That they have always preferred the speculative to the exact sciences is easily explained, but not easily to be altered.

THE EFFICIENCY & DURATION OF INCANDESCENT ELECTRIC LAMPS.

The report of a special committee appointed by the President of the Franklin Institute to determine the efficiency and duration of certain kinds of incandescent electric lamps has just been issued. A test of this description upon a large scale, and including every kind of known lamp, might have been of the utmost value; as it is, we think it would be unfair to certain firms whose lamps have been tried to consider the report as anything else than the result of a competition between the United States Electric Lighting Company, represented by Mr. Weston, and the Edison Company. The results, however, even so far as they concern the Edison and Weston lamps, are very interesting, as showing the behaviour of the lamps at different periods of their existence. The Tamadine carbon of the Weston lamps will be found to present some curious variations in resistance, and intensity of light, while on the other hand the Edison lamp is remarkably constant in its obedience to known laws. By the report we notice that a code had been prepared by Mr. Upton, representing the interest of the United States and the Edison Companies, specifying how the test should be conducted. The Brush-Swan and the Bernstein companies declined to enter their lamps, while a number of Woodhouse and Rawson lamps, obtained from the Van de Poele Company, and two grades of the Stanley-Thompson lamp, made by the Union Switch and Signal Company, of Pittsburg, were entered, not by the makers but by the Franklin Institute. The president of the Franklin Institute subsequently entered, for efficiency measurement and for such a test of duration as circumstances would permit, a lot of Weston lamps, furnished by Mr. Weston; a lot of Woodhouse and Rawson lamps, received from the Edison Lamp Company; and a lot of White lamps from the Electrical Supply Company. The examiners were Lieut. J. B. Murdock, U.S.N.; Ensign L. Duncan, of the same service; Professor William D. Marks, and Dr. G. M. Ward. Comprehensive arrangements were made, we are informed, to ensure the best conditions being obtained in each case, and precautions of a somewhat extraordinary nature were taken in order to prevent any possibility of the lamps being tampered with. The tests began with the following lamps entered:—20 Weston, 110·5 volts, Tamadine carbon; 20 Edison 94—100 volts; 10 Woodhouse and Rawson 55 volts; 10 Stanley-Thompson, 96 volts, and 10 Stanley-Thompson, 44 volts. The Tamadine carbon of the Weston lamps had been prepared by chemically treating guncotton in the form of flat sheets to separate the nitryl from the cellulose. The resulting cellulose product is a tough, firm translucent substance, from which the strips are cut in a sinuous form, and carbonised. The carbon is rectangular in cross section, but is placed in the lamps so that at the shanks the longer side of the rectangle is in the line of the shanks instead of at right angles, as in most other lamps. The connections are made at the terminals, with minute steel screw bolts and nuts, setting up with platinum washers. The bending of the carbon turns the long side of the rectangle, so that it lies in different directions at different points. The Edison and Woodhouse and Rawson lamps are too well known to need description. The Stanley-Thompson lamps had carbons apparently made from thread.

The method adopted in taking photometric measurements presents some points of novelty, no doubt due to the presence of two naval officers upon the committee. Quoting from the report we learn that the measurements of the spherical illuminating power of the lamps were made with the object of obtaining the average candle-power of the lamps, and of avoiding the doubt as to the total amount of light which might arise from the various forms of carbon (many of them distorted in manufacture) used by different makers. Sixty-five measurements or more were made on each lamp. The method pursued may be more easily understood by a comparison with the parallels and meridians of the earth, referring to points by their latitude and longitude. The lamp was placed in a vertical position with the plane of the shanks of the carbon at right angles to the photometer bar. The side nearest the bar was marked for future reference. The top and bottom of the lamp were assumed as the north and south poles respectively, and the vertical circle at right angles to the plane of the shanks of the carbon as the prime meridian. The lamp, after adjustment as above, was first rotated horizontally, and thirteen measurements were made in the equator at equal angles of thirty degrees, the last checking on the first. The mean of these measurements gave the "mean horizontal intensity." Starting again from the first position, the lamp was rotated in the plane of the prime meridian, and thirteen measurements were made at equal intervals at thirty degrees, the last checking the first, and making four measurements of the point 0° latitude, 0° longitude. The mean of these four was called the "standard reading." If any noticeable discrepancy was seen the measurements at this point were repeated. As this point was that on which the calculations for the duration test were based, its careful determination was essential. The lamp was then moved 45° horizontally, so that 0° latitude, 45° longitude E. was towards the photometer. It was then rotated in the vertical plane passing through that point, and thirteen measurements made as before, at intervals of 30°, the last checking the first. The lamp was next moved 45° horizontally, so that 0° latitude, and 90° longitude E. was towards the photometer, and 13 measurements made in that meridian as before. Lastly, the lamp was rotated till 0° latitude, 135° longitude E. was towards the photometer and twelve thirty degree measurements made in that meridian, checking with a thirteenth. This makes a total of 65 measurements on each lamp. As the sockets in use with all the lamps prevented the exit of any light from the bottom or south pole of the lamp, the reading at that point was always taken as zero. The measurements were combined as follows:—

The mean of four readings at the north pole of lamp	1
Four measurements on each of the parallels of 60° N. and 60° S. on the prime meridian and 90° meridian circle	8
Eight measurements on each of the parallels of 30° N. and 30° S. at the intersection of the meridian circles of 0°, 45°, 90°, and 135°	16
Twelve measurements, 30° apart, on the equator	12
One zero reading for south pole (base of lamp)	1
Making a total of	38

By laying down the points on a sphere it will be found that they are nearer at the equator than at the poles. The average of the illuminating power at these 38 points is taken at the mean spherical intensity of illuminating power. Fig. 1 shows the location of the thirty-eight points. It is a photograph of a

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Mueller lamp of nearly spherical shape, around which four rubber bands are stretched to show the four meridian circles, and one rubber band to represent the equator. The small black patches show the thirty-eight points. In order to determine whether the arithmetical mean of these observations gives a close approximation to the mean spherical intensity, calculable from the observations taken, the sphere may be divided into zones, each extending 15° on either side of the equator and the parallels of 30° and 60°, and the spherical intensity be calculated from the area of these zones and the mean candle-power in each. (See Fig. 2.)

The surface of the sphere is developed at the equator by means of a tangent cylinder, at 30° and 60° latitude, by means of a tangent conical frustra, and at the poles by tangent discs.

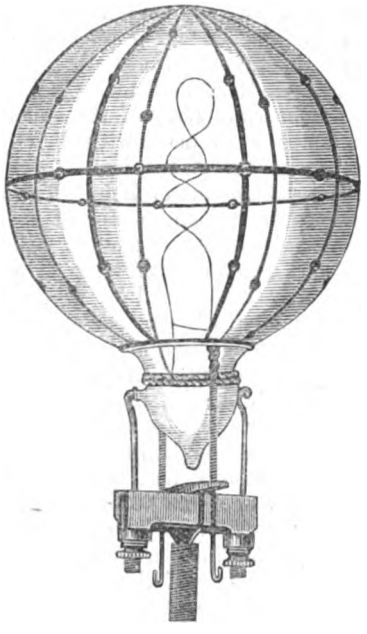

Fig 1.

If now we multiply the mean intensity of illumination of each zone by its area, and divide the sum of these products by the whole area of the sphere, we obtain with very close accuracy the mean spherical intensity of illumination. The following formula gives the method :—

$$\frac{\text{Mean eq.} + \text{mean } 60° \text{ lat.} + 1{\cdot}73 \text{ mean } 30° \text{ lat.} + 0{\cdot}131 \text{ poles}}{3{\cdot}861} = \text{mean spherical candle-power.}$$

This method when compared with that in use gives

Stanley (large), No. 26...13·09 cndles. Method in use .....13·10 cndles.
Edison, No. 2..... ....14·30 ,, ,, ,, ...14·38 ,,

The method adopted yielded results giving slight preponderance to the illumination at the equator, but the difference was small, and this method lent itself readily to the mechanical conditions of the lamp-holder.

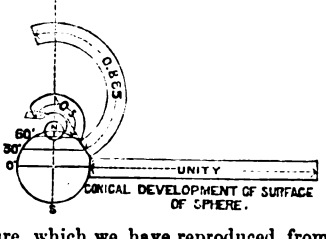

Fig. 2.—This figure, which we have reproduced from the *Journal* of the Franklin Institute, should show the tangents.

The standard Letheby-Bunsen photometer, with a 60in. bar, was used in the efficiency tests, and the Methven standard two-candle slit in all the photometric measurements. Although only twenty-three Edison lamps were required to be measured by the duration test, a larger number were examined. The first twenty of the lamps were tested for duration, and curves were calculated from them ; but few peculiarities were observed. One of these lamps, through a peculiar distortion of the carbon, gave an almost circular curve of horizontal distribution ; the curves of the others were essentially the same. We are further informed that the lamps were taken at random from 400 furnished by the company.

Fourteen of the Stanley-Thompson 96 volt lamps were tested for efficiency, four of the original lot having been broken in fitting them to sockets preparatory to the test of duration, and four others tested in their places. The high potential of the 44 volt lamps 37, 41, and 51 was due to an error of calculation which, corrected after the efficiency test, gave the high figures recorded. These lamps gave the highest average of efficiency of any lot under test, but varied considerably from each other. The curves were essentially the same as those of the 96 volt lamps, except in giving less light at the top of the lamp. They were also taken at random from a lot of 50. Of the Woodhouse and Rawson lamps two lots were tested, the results obtained being generally the same. The first lot were marked 55 volts, and were taken from 25 lamps furnished. There were slight irregularities in the curves obtained from them, due to the fact of the lamp being mounted on a Swan spring socket. In the efficiency measurements, the motion and vibration of this socket in moving it through the various positions occupied, prevented as accurate a measurement as in other cases where the lamp was held rigidly. The second set of this firm's lamps, selected from 50 furnished, were marked 50 volts, and a paper accompanied them from the makers, we are informed, invoicing them as "20 candle-power 50 volt lamps." They were tested by the committee, as the duration test on the former lot was unsatisfactory by reason of many of the lamps being connected two in series. On setting the new lot up at 50 volts they were found to give only 12 spherical candles and to have an efficiency of about 5 watts of candle. A duration test of 300 hours, says the report, was all that could be allotted to these lamps, and would determine nothing if the lamps were tested at so low a candle-power. As the resistance of the lamps cold was the same as some of the first lot of 55 volts, the committee determined to test the second lot at that potential also.

The White lamps were taken from a lot of 24. The carbons, which, as we have mentioned, appeared to be made of thread, had a circular cross section and were heavily treated. The curves of the whole of these lamps were almost identical. The lamps decreased in resistance during the duration test. The average cold resistance before use of several lamps of the same lot was found to be 102 ohms, and those under test probably averaged about the same. On the subject of the Weston lamps some controversy took place between Mr. Weston and the members of the committee ; Mr. Weston having had, it would appear, very much his own way in the matter. His lamps were of 110·5 volts for the first lot, and the light curves obtained from them were very similar in form. In one the major axis of the curve of horizontal illumination laid in the direction of 30°—210°, and in making up the average of 20 another lamp was substituted for this one. The 70 volt paper carbon lamps of the same company were 10 in number, selected from a lot of 33 received from Mr. Weston, and were tested for efficiency, and afterwards subjected to a duration test of 523 hours. In reviewing the results of the tests the committee, and doubtless many other people, have noticed discrepancies in the candle-power. This was unavoidably the case ; from the continuous nature of the test no repetition of the work was possible, and the discrepancies referred to were shown to be such only by observation on subsequent days.

Some general remarks on the subject of the tests of each lot of lamps are given. The Edison lamps behaved with great uniformity, there being in all a gradual increase of resistance throughout the test. One volt was assumed to cause a difference of mean horizontal intensity of one candle. The same allowance for candle-power per volt was made with the 96 volt Stanley-Thompson lamps as with the Edison. In correcting the 44 volt lamps an allowance of 1·5 spherical candle was made for one volt.

The allowance for the Woodhouse and Rawson lamps was 1·5 spherical candle-power per volt. The resistance of the second lot gradually decreased for three days, the candle-power rising and then falling as the resistance increased. All

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EFFICIENCY AND DURATION TESTS.

Name.	No. of lamp.	FIRST STAGE. Volts observed.	Amperes.	Watts.	Candles at commencement. Observed	Spherical.	Mean horizontal.	Watts per spherical candle.	Reduction Factor.	Resistance. Cold.	Hot.	LAST STAGE. Hours of test.	Total time observed in hours.	Volts.	Amperes.	Watts.	Candles. Observed	Spherical.	Mean horizontal.	Resistance. Hot.	Cold.	Discolouration.	REMARKS.
Edison.	1	98·9	·690	68·24	15·90	15·31	18·81	4·45	·96	260	143·3	1054·15	1065·45	98·8	·639	63·13	7·3	7·0	8·6	281	154·6	3	
	2	98·9	·703	69·44	13·95	14·38	17·62	4·83	1·03	252	140·7	1053·30	1065·0	97·7	·646	63·11	7·3	7·5	9·2	267	151·2	2	
	3	95·8	·711	68·12	16·32	14·87	18·03	4·58	·91	241	134·7	1053·00	1064·30	94·8	·662	62·75	8·3	7·6	9·2	257·0	143·2	2	No. 4 approximate to this.
	5	97·8	·718	70·21	17·32	16·41	20·28	4·27	·95	244	136·2	1053·00	1064·30	97·1	·658	63·89	8·1	7·7	9·5	260·0	147·6	2·5	
	6	99·9	·692	69·13	16·07	14·67	17·98	4·71	·91	264	144·4	1053·00	1064·30	99·1	·642	63·62	8·5	7·7	9·5	279·0	154·4	2·5	No. 7 gave results similar to No. 3.
	8	97·9	·729	71·37	19·97	16·81	20·32	4·24	·84	239	134·3	1053·00	1064·45	97·0	·674	65·37	9·4	7·9	9·6	259	143·9	3	No. 9 similar to No. 3.
	10	97·8	·714	69·83	14·92	14·58	18·54	4·79	·98	246	137	1053·00	1064·30	96·9	·667	64·63	7·5	7·4	9·4	259	145·3	2	No. 18 similar to this.
	11	98·7	·711	70·18	18·25	16·66	20·98	4·21	·91	250	138·8	1053·15	1064·45	97·9	·659	64·51	8·0	7·3	9·2	269	148·6	3	No. 12 similar to No. 2.
	13	96·7	·723	69·91	16·67	15·44	19·00	4·52	·93	235	133·7	1035·00	1064·30	96·1	·89	66·21	8·3	7·7	9·5	247	139·5	2·5	No. 14 similar to foregoing.
	15	99·7	·692	68·99	14·30	15·65	19·74	4·40	1·09	255	144·1	265	295·00	98·8	·665	65·71	11·2	12·2	15·4	...	148·6	2	Carbon broke at side of loop.
	16	95·7	·714	68·33	20·30	16·09	20·26	4·24	·79	239	134·0	1053·00	1064·30	94·8	·665	63·04	8·9	7·0	8·8	256	142·6	2·5	No. 17 similar to No. 11.
	20	100·7	·696	70·09	16·23	15·82	19·56	4·43	·97	256	144·7	1053·00	1064·30	100·0	·637	63·70	6·9	6·7	8·3	270	157·0	2·0	No. 19 similar to No. 6.
Stanley-Thompson.	1	44·4	1·096	48·66	15·2	12·39	15·36	3·92	·82	80·7	40·51	290·3	308·45	43·95	·964	42·36	8·0	6·6	8·2	45·59	...	4·5	Carbon broke at side of loop.
	2	44·45	1·039	46·18	14·0	11·10	13·38	4·16	·79	84	42·78	101·15	143·0	44·10	·980	43·22	13·1	10·4	12·6	45	...	3·5	Ditto.
	3	43·90	1·068	46·88	19·70	15·88	19·46	2·95	·81	79·5	41·10	101·00	136·3	46·9	·980	45·96	13·9	11·3	13·9	47·86	...	4·5	Ditto.
	4	43·9	1·080	47·41	18·3	14·07	17·40	3·36	·77	79·2	40·65	173·00	178·00	44·55	1·000	44·55	12·5	9·6	11·9	44·55	...	4·0	Carbon broke at middle of loop.
	8	43·9	1·044	45·83	12·1	10·58	12·92	4·33	·87	79·8	42·05	1035·30	1047·00	44·15	·896	39·55	5·1	4 4	5 4	49·27	92·0	4·0	Nos. 6, 7, and 9 broke at 288, 303, and 39 hours.
	10	43·75	1·031	45·10	19·3	15·94	19·29	2·83	·83	82·4	42·3	202·15	206·15	43·55	·896	39·02	11·3	9·4	11·4	48·6	...	3·5	Broke at side of loop.
	11	43·90	1·059	46·49	19·1	15·19	19·28	3·06	·80	79·0	41·45	265·00	275·00	43·50	·901	39·19	7·4	5·9	5·5	48·28	...	4·5	Carbon broke at loop.
	26	96·4	·578	55·72	15·85	13·10	15·73	4·25	·82	330	166·8	52·45	78·15	95·1	·554	52·69	14·2	11·6	13·9	171·7	...	2	Broke side of loop. No. 28 broke at 213, 29 at 176.
	30	96·3	·544	53·35	15·35	12·94	15·65	4·12	·84	339	173·8	1053·15	106·45	96·1	·470	45·17	6·1	5·1	6·2	204·5	389	3	33 at 256.
	34	96·4	·558	53·79	17·05	14·17	16·95	3·79	·89	349	172·8	502·15	524·45	96·5	·495	47·76	10·0	8·9	10·6	195·0	...	3·5	Carbon broke at side of loop.
	37	97·2	·534	51·90	17·55	14·28	17·29	3·63	·81	350	182·0	881·3	881·3	95·9	·445	42·67	8·3	6·7	8·1	215·5	...	2·5	Broke at side of loop.
White, Woodhouse and Rawson.	1	55·3	1·162	64·26	17·7	19·01	22·14	3·38	1·07	98	47·59	3·15	41·00	...	...	...	19·4	20·8	24·1	...	...	3	Broke at side of loop.
	3	55·2	1·162	64·14	17·6	20·06	24·39	3·19	1·07	98	47·50	213·30	213·30	54·2	1·025	55·55	10·5	12·0	14·6	52·88	...	4·5	Broke at middle of loop.
	9	55·95	1·125	62·94	18·50	18·43	22·01	3·41	1·00	106	49·73	715·3	715·3	55·5	·984	54·61	7·0	7·0	8·3	56·40	...	5	Broke at side of loop.
	30	55·00	1·167	64·18	17·18	18·52	22·73	3·46	1·08	100	47·13	320·45	332·15	54·90	1·117	61·32	9·7	10·5	12·9	49·15	101	4	No. 31 lasted 227 hours, Nos. 32 and 33 331 hours.
	34	55·00	1·147	63·08	16·68	16·91	20·78	3·73	1·01	100	47·95	199·30	234·30	55·15	1·127	62·15	16·6	16·8	20·7	48·94	...	3	Broke at side of loop.
	35	54·95	1·139	62·58	21·14	19·56	23·53	3·20	1·01	100	48·24	271·45	272·15	54·95	1·071	58·85	14·4	13·4	16·1	51·31	...	3·5	Ditto.
		The re	maini	ng four	lamps	of this	firm	lasted	330,	176,	223, a	nd 212 h	ours resp	ectively	Lamps	Nos.	30 to	39 are	second	lot su	pplied.		
	1	50·00	1·033	51·65	12·78	10·80	13·08	4·78	·85	...	48·4	300·45	312·15	49·9	1·127	56·23	13·8	11·7	14·2	44·28	94	3·5	Nos. 2 and 3 lasted 311 hours.
	4	49·95	1·020	50·95	16·75	14·17	17·17	3·59	·85	...	48·97	299·45	311	49·95	1·054	52·64	13·2	11·2	13·6	47·39	99	3	Nos. 5 and 6 lasted 310 and 228 hours.
	7	50·00	1·001	50·05	16·46	13·99	16·98	3·57	·85	...	49·95	131·45	159·45	49·75	1·019	50·69	18·0	15·3	18·5	48·82	...	3·5	No. 8 lasted 309 hours.
						The t	wo first	t Weston		110·5	volt la	mps last	ed 227 a	nd 46 ho	urs re	spectiv	ely.						Nos. 9 and 10 lasted 165 and 309 hours.
Weston.	3	111·3	·502	55·87	16·32	14·28	15·77	3·82	·87	...	221·7	1053	1065	109·9	·449	49·34	6·0	5·2	5·7	244·8	442	2·0	Nos. 4 and 5 lasted 106 and 320 hours.
	6	111·5	·501	55·86	14·00	11·25	12·18	4·96	·81	402	222·6	1053	1065	110·6	·494	54·63	9·7	7·9	8·5	223·9	424	2·0	
	7	115·5	·543	60·54	21·95	18·32	20·10	3·30	·83	414	205·3	1053	1064	110·5	·379	41·87	2·7	2·2	2·4	291·6	544	2·0	
		No. 8	lasted	141 h	ours ;	No. 10	simila	r to	No. 9,	823 h	ours ; N	o. 11, 169	hours ; a	nd the t	wo next	t 81 an	d 255	hour	s resp	ectively			
	9	111·4	·530	59·04	21·9	16·53	17·97	3·57	·75	409	210·2	1053	1064	110·1	·455	50·09	6·9	5·2	5·7	242·0	456	2·0	
	14	111·4	·549	61·15	24·65	19·14	21·31	3·19	·78	409	202·9	196·15	212·3	111·8	·404	45·16	3·6	2·8	3·1	276·7	...	1	Broke at middle of loop.
	15	111·4	·491	54·69	11·97	9·78	10·45	5·59	·82	408	226·9	193	193	111·0	·454	50·39	7·0	5·7	6·1	244·5	...	1	Broke at shank.
	16	111·4	·513	57·14	18·12	15·03	16·43	3·80	·83	399	217·2	1053	1064	110·4	·468	51·66	8·5	7·1	7·7	235·9	457	3	No. 17 lasted 40 hours.
	18	111·4	·540	60·15	20·97	16·71	17·95	3·60	·80	405	206·3	1053	1064	110·0	·418	45·98	4·0	3·2	3·4	263·2	488	2·0	
	19	111·4	·561	62·49	27·95	20·30	22·93	3·07	·73	402	198·6	52	65	109·8	·491	53·91	13·7	10·0	11·3	223·6	...	2	Broke at side of loop.
	20	111·4	·562	62·60	21·68	19·44	20·88	3·22	·90	392	198·2	1053	1064	110·3	·484	53·38	7·9	7·1	7·6	227·9	not tak'n	2	Nos. 51 and 54 lasted 259 and 524 hours.
	55	70·4	1·002	70·54	20·80	17·11	18·83	4·12	·82	144	70·26	512	523	70·0	·969	67·83	14·4	11·8	13·0	72·24	147	2	
	56	70·4	·969	68·21	18·10	15·07	16·96	4·52	·83	148	72·65	512	523	70·0	·964	67·48	13·9	11·5	15·6	72·61	147	2	
	58	70·5	·952	67·11	19·80	16·95	18·67	3·96	·86	153	74·05	512	523	70·0	·915	64·05	12·9	11·1	12·2	76·50	155	2·5	Nos. 59 and 61 lasted 222 and 523 hours.
	62	70·4	·971	68·35	18·02	14·42	16·03	4·74	·80	148	72·50	511	523	69·8	·932	65·05	11·3	9·0	10·0	74·89	152	2	No. 63, similar to 62, broke at 523 hours.
	64	70·4	·962	67·72	18·00	15·32	16·76	4·42	·85	149	73·18	462	462	69·9	·946	66·12	16·4	13·9	15·1	73·89	...	2	Carbon broke.

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these lamps were much discoloured, and, as a bare possibility, received more than their proper potential.

The White lamps decreased in resistance, the average decrease being 2·5 ohms in 100 hours; the candle-power increasing greatly. The resistance then began to decrease and the candle-power to fall off, but after 250 hours the candle-power was still higher than in the preliminary efficiency test. The correction was 1·5 spherical candle per volt.

The Weston 110·5 volt lamps increased rapidly in resistance at first, the candle-power falling greatly; a correction of one spherical candle per volt was assumed. Great difficulty, we are informed, was experienced with all the Weston lamps in getting the point of 0° latitude 0° longitude exactly towards the photometer. Owing to the peculiar oblique position of the major axis of the curve of horizontal illumination in relation to the plane of the carbon shanks, a slight rotation of the lamp was noticed; the socket materially affecting the photometer reading. A fall of candle-power which took place in lamp No. 62 may have been partially due to this. The resistance, however, showed a deterioration in the lamp as well. The resistance of the 70 volt lamps, as a whole, remained fairly constant, the changes being but slight in either direction. The correction allowed was one and three-tenth spherical candle-power per volt. Very great care was evidently taken to do full justice to Mr. Weston.

The following table shows the mean preliminary readings taken of the various lots of lamps:—

Name.	No. of Lamps.	Volts.		Amps. mean.	Watts mean.	Candles.		Watts per sphrical. candle	Resist. cold.	Candles per elec. h.-p.	
		Marked	Observed.			Mean Spherical.	Mean Horizontal			Spherical.	Horizontal
Edison	31	96·9	97·57	·7065	68·92	15·47	19·24	4·459	247·5	169·2	216·4
Stanley	14	96	96·56	·554	53·61	13 59	16·30	4·04	345·1	189·1	226·3
Ditto	10	44	43·98	1·053	46·32	13·42	16·44	3·544	81·1	216·1	264·8
Woodhouse & Rawson	11	55*	55·53	1·006	55·82	15·64	18·68	3·605	117·3	209·0	249·6
Ditto	10	55†	55·00	1·178	64·77	18·30	22·13	3·56	100·2	210·8	254·0
White	10	50	49·99	1·017	50·83	12·44	15·05	4·05	not taken	182·6	220·9
Weston	23	110·5	111·42	·530	59·04	16·43	18·07	3·713	407·9	209·8	230·7
Ditto	10	70	70·4	·968	68·09	15·18	16·85	4·51	150·0	166·3	184·6

* 1st lot. † 2nd lot.

Referring to the tables, in which we have endeavoured to include the whole of the information contained in the very many tables in the report, we may mention that of the Edison lamps the readings of Nos. 4, 7 and 9 were very similar to those of No. 3, No. 12 approximated to No. 2, but gave a slight excess of light, while No. 14 approximated to No. 13, taking however ·659 ampere at the finish of test. The carbon of No. 15 broke at the side of the loop at the 265th hour, this being the only loss. No. 17 was similar to No. 11, No. 18 to No. 10, and No. 19 to No. 6. The first four of the Stanley-Thompson lamps broke down at the times specified upon the table, the fault being the breaking of the carbon at the side of the loop in the first three cases, and at the middle of the loop in the fourth. Nos. 6 and 7 of these lamps lasted but 288 and 303 hours, while No. 9 broke at the side of the loop at the 39th hour. No. 12 was destroyed by too high a potential, whilst of the others we have omitted from the table, No. 28 lasted 233 hours; No. 29, 176 hours; No. 33, 256 hours; Nos. 35 and 99, 3 and 36 hours; 300, 4 hours; No. 41, 682 hours. The failure of all these was due to the breaking of the carbon. The Woodhouse and Rawson lamps not given in the table are Nos. 4, 5, 6, 7, 8, 10, 18, 31, 32, and 33. These broke at periods ranging from 117 to 422 hours. The remaining four lasted 330, 176, 223, and 212 hours respectively. Nos. 2 and 3 of the White lamps both lasted 211 hours, whilst Nos. 5, 6, 8, 9, and 10, endured 310, 228, 309, 165, and 309 hours in each case. The first two of the Weston 110·5 volt lamps gave out after 227 and 46 hours. Those omitted from the table are Nos. 4, 5, 7, 51, 54, and 59, which lived 106, 320, 40, 259, 524, and 222 hours; Nos. 61 and 63 reached the 523rd hour. The failures, as in other cases, were caused by the breaking of the carbon. In glancing over the table some curious discrepancies in the candle-power and resistance given by these latter lamps at different periods of their lives will be noticed; but we refrain from comment, preferring to leave our readers to form their own conclusions as to the respective merits of at least the two most prominent representatives of electric lighting in America.

BRITISH ASSOCIATION MEETING AT ABERDEEN.

PRESIDENTIAL ADDRESS BY THE RIGHT HON. SIR LYON PLAYFAIR, K.C.B., M.P., F.R.S.

I. *Visit to Canada.*

LADIES AND GENTLEMEN:

Our last meeting at Montreal was a notable event in the life of the British Association, and even marked a distinct epoch in the history of civilisation. It was by no mere accident that the constitution of the Association enabled it to embrace all parts of the British Empire. Science is truly catholic, and is bounded only by the universe. In relation to our vast empire, science, as well as literature and art, are the common possession of all its varying people. The United Kingdom is limited to 120,800 square miles, inhabited by 35 millions of people; but the empire as a whole has 8½ millions of square miles, with a population of 305 millions. To federate such vast possessions and so teeming a population into a political unit is a work only to be accomplished by the labours and persistent efforts of perhaps several generations of statesmen. The federation of its science is a subject of less dimensions well within the range of experiment. No part of the British Empire was more suited than Canada to try whether her science could be federated with our science. Canada has lately federated distinct provinces, with conflicting interests arising from difference of races, nationalities, and religions. Political federation is not new in the history of the world, though it generally arises as a consequence of war. It was war that taught the Netherlands to federate in 1619. It was war which united the States in America; federated Switzerland, Germany, and Austria, and unified Italy. But Canada formed a great national life out of petty provincial existences in a time of profound peace. This evolution gave an immense impulse to her national resources. The Dominion still requires consolidation in its vast extent, and applied science is rapidly effecting it. Canada, with its great expanse of territory, nearly as large as the United States, is being knit together by the iron bands of railways from the Gulf of St. Lawrence to the Pacific Ocean, so that the fertile lands of Ontario, Manitoba, Columbia, and the North-Western territories will soon be available to the world. Still, practical science has much to accomplish. England and France, with only one-fifth the fertile area of Canada, support 80 millions of people, while Canada has a population not exceeding 5 millions.

A less far-seeing people than the Canadians might have invited the applied science which they so much require. But they knew that without science there are no applications. They no doubt felt with Emerson—

> "And what if Trade sow cities
> Like shells along the shore,
> And thatch with towns the prairie broad
> With railways ironed o'er;
> They are but sailing foam-bells
> Along Thought's causing stream,
> And take their shape and sun-colour
> From him that sends the dream."

So it was with a far-reaching foresight that the Canadian Government invited the British Association for the Advancement of Science to meet in Montreal. The inhabitants of Canada received us with open arms, and the science of the Dominion and that of the United Kingdom were welded. We found in Canada, as we had every reason to expect, men of manly and self-reliant character, who loved not less than we did the old home from which they had come. Among them is the same healthiness of political and moral life, with the same love of truth which distinguishes the English people. Our great men are their great men; our Shakspeare, Milton, and Burns belong to them as much as to ourselves; our Newton, Dalton, Faraday, and Darwin are their men of science as much as they are ours. Thus a common possession and mutual sympathy made the meeting in Canada a successful effort to stimulate the progress of science, while it established, at the same time, the principle that all people of British origin—and I would fain include our cousins in the United States—possess a common interest in the intellectual glories of their race, and ought, in science at least, to constitute part and parcel of a common empire, whose heart may beat in the small islands of the Northern seas, but whose blood circulates in all her limbs, carrying warmth to them and bringing back vigour to us. Nothing can be more cheering to our Association than to know that many of the young communities of English-speaking people all over the globe—in India, China, Japan, the Straits, Ceylon, Australia, New Zealand, the Cape—have founded scientific societies in order to promote the growth of scientific research. No doubt science, which is only a form of truth, is one in all lands, but still its unity of purpose and fulfilment received an important practical expression by our visit to Canada. This community of science will be continued by the fact that we have invited Sir William Dawson, of Montreal, to be our next President at Birmingham.

II. *Science and the State.*

I cannot address you in Aberdeen without recollecting that when we last met in this city our president was a great prince. The just verdict of time is that, high as was his royal rank, he has a far nobler claim to our regard as a lover of humanity in its widest sense, and especially as a lover of those arts and sciences which do so much to adorn it. On September 14, 1859, I sat on this platform and listened to the eloquent address and wise counsel of the Prince Consort. At one time a member of his household, it was my privilege to co-operate with this illustrious prince in many questions relating to the advancement of science. I naturally, therefore,

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turned to his presidential address to see whether I might not now continue those counsels which he then gave with all the breadth and comprehensiveness of his masterly speeches. I found, as I expected, a text for my own discourse in some pregnant remarks which he made upon the relation of Science to the State. They are as follows:—"We may be justified in hoping . . . that the Legislature and the State will more and more recognise the claims of science to their attention, so that it may no longer require the begging-box, but speak to the State like a favoured child to its parent, sure of his paternal solicitude for its welfare; that the State will recognise in science one of its elements of strength and prosperity to foster which the clearest dictates of self-interest demand."

This opinion, in its broadest sense, means that the relations of science to the State should be made more intimate because the advance of science is needful to the public weal.

The importance of promoting science as a duty of statecraft was well enough known to the ancients, especially to the Greeks and Arabs, but it ceased to be recognised in the dark ages, and was lost to sight during the revival of letters in the fifteenth and sixteenth centuries. Germany and France, which are now in such active competition in promoting science, have only publicly acknowledged its national importance in recent times. Even in the last century, though France had its Lavoisier and Germany its Leibnitz, their Governments did not know the value of science. When the former was condemned to death in the Reign of Terror, a petition was presented to the rulers that his life might be spared for a few weeks in order that he might complete some important experiments, but the reply was, "The Republic has no need of savants." Earlier in the century the much-praised Frederick William of Prussia shouted with a loud voice, during a graduation ceremony in the University of Frankfort, "An ounce of mother-wit is worth a ton of university wisdom." Both France and Germany are now ashamed of these utterances of their rulers, and make energetic efforts to advance science with the aid of their national resources. More remarkable is it to see a young nation like the United States reserving 150,000,000 acres of national lands for the promotion of scientific education. In some respects this young country is in advance of all European nations in joining science to its administrative offices. Its scientific publications, like the great paleontological work embodying the researches of Professor Marsh and his associates in the Geological Survey, are an example to other Governments. The Minister of Agriculture is surrounded with a staff of botanists and chemists. The Home Secretary is aided by a special Scientific Commission to investigate the habits, migrations, and food of fishes, and the latter has at its disposal two specially constructed steamers of large tonnage. The United States and Great Britain promote fisheries on distinct systems. In this country we are perpetually issuing expensive Commissions to visit the coasts in order to ascertain the experiences of fishermen. I have acted as chairman of one of these Royal Commissions, and found that the fishermen, having only a knowledge of a small area, gave the most contradictory and unsatisfactory evidence. In America the questions are put to Nature, and not to fishermen. Exact and searching investigations are made into the life-history of the fishes, into the temperature of the sea in which they live and spawn, into the nature of their food, and into the habits of their natural enemies. For this purpose the Government give the co-operation of the navy, and provide the Commission with a special corps of skilled naturalists, some of whom go out with the steamships and others work in the biological laboratories at Wood's Hall, Massachusetts, or at Washington. The different universities send their best naturalists to aid in these investigations, which are under the direction of Mr. Baird, of the Smithsonian Institution. The annual cost of the Federal Commission is about £40,000, while the separate States spend about £20,000 in local efforts. The practical results flowing from these scientific investigations have been important. The inland waters and rivers have been stocked with fish of the best and most suitable kinds. Even the great ocean which washes the coasts of the United States is beginning to be affected by the knowledge thus acquired, and a sensible result is already produced upon the most important of its fisheries. The United Kingdom largely depends upon its fisheries, but as yet our Government have scarcely realised the value of such scientific investigations as those pursued with success by the United States. Less systematically, but with great benefit to science, our own Government has used the surveying expeditions, and sometimes has equipped special expeditions to promote natural history and solar physics. Some of the latter, like the voyage of the "Challenger," have added largely to the store of knowledge; while the former, though not primarily intended for scientific research, have had an indirect result of infinite value by becoming training schools for such investigators as Edward Forbes, Darwin, Hooker, Huxley, Wyville Thomson, and others.

In the United Kingdom we are just beginning to understand the wisdom of Washington's farewell address to his countrymen, when he said: "Promote as an object of primary importance institutions for the general diffusion of knowledge. In proportion as the structure of a government gives force to public opinion, it is essential that public opinion should be enlightened." It was only in 1870 that our Parliament established a system of national primary education. Secondary education is chaotic, and remains unconnected with the State, while the higher education of the universities is only brought at distant intervals under the view of the State. All great countries except England have Ministers of Education; but this country has only ministers who are the managers of primary schools. We are inferior even to smaller countries in the absence of organised State supervision of education. Greece, Portugal, Egypt, and Japan have distinct Ministers of Education, and so also among our colonies have Victoria and New Zealand. Gradually England is gathering materials for the establishment of an efficient Education Minister. The Department of Science and Art is doing excellent work in diffusing a taste for elementary science among the working classes. There are now about 78,000 persons who annually come under the influence of its science classes, while a small number of about two hundred, many of them teachers, receive thorough instruction in science at the excellent school in South Kensington, of which Professor Huxley is the dean. I do not dwell on the work of this Government department, because my object is chiefly to point out how it is that science lags in its progress in the United Kingdom owing to the deficient interest taken in it by the middle and upper classes. The working classes are being roused from their indifference. They show this by their selection of scientific men as candidates at the next election. Among these are Professors Stuart, Roscoe, Maskelyne, and Rücker. It has its significance that such a humble representative of science as myself received invitations from working-class constituencies in more than a dozen of the leading manufacturing towns. In the next Parliament I do not doubt that a Minister of Education will be created as a nucleus round which the various educational materials may crystallise in a definite form.

III. *Science and Secondary Education.*

Various Royal Commissions have made inquiries and issued recommendations in regard to our public and endowed schools. The Commissions of 1861, 1864, 1868, and 1873 have expressed the strongest disapproval of the condition of our schools, and, so far as science is concerned, their state is much the same as when the Duke of Devonshire's Commission in 1873 reported in the following words:—"Considering the increasing importance of science to the material interests of the country, we cannot but regard its almost total exclusion from the training of the upper and middle classes as little less than a national misfortune." No doubt there are exceptional cases and some brilliant examples of improvement since these words were written, but generally throughout the country teaching in science is a name rather than a reality. The Technical Commission which reported last year can only point to three schools in Great Britain in which science is fully and adequately taught. While the Commission gives us the consolation that England is still in advance as an industrial nation, it warns us that foreign nations, which were not long ago far behind, are now making more rapid progress than this country, and will soon pass it in the race of competition unless we give increased attention to science in public education. A few of the large towns, notably Manchester, Bradford, Huddersfield, and Birmingham, are doing so. The working classes are now receiving better instruction in science than the middle classes. The competition of actual life asserts its own conditions, for the children of the latter find increasing difficulty in obtaining employment. The cause of this lies in the fact that the schools for the middle classes have not yet adapted themselves to the needs of modern life. It is true that many of the endowed schools have been put under new schemes, but as there is no public supervision or inspection of them, we have no knowledge as to whether they have prospered or slipped back. Many corporate schools have arisen, some of them, like Clifton, Cheltenham, and Marlborough Colleges, doing excellent educational work, though as regards all of them the public have no rights and cannot enforce guarantees for efficiency. A Return just issued, on the motion of Sir John Lubbock, shows a lamentable deficiency in science teaching in a great proportion of the endowed schools. While twelve to sixteen hours per week are devoted to classics, two or three hours are considered ample for science in a large proportion of the schools. In Scotland there are only six schools in the Return which give more than two hours to science weekly, while in many schools its teaching is wholly omitted. Every other part of the kingdom stands in a better position than Scotland in relation to the science of its endowed schools. The old traditions of education stick as firmly to schools as a limpet does to a rock; though I do the limpet injustice, for it does make excursions to seek pastures new. Are we to give up in despair because an exclusive system of classical education has resisted the assaults of such cultivated authors as Milton, Montaigne, Cowley, and Locke? There was once an enlightened Emperor of China, Chi Hwangti, who knew that his country was kept back by its exclusive devotion to the classics of Confucius and Mencius. He invited 500 of the teachers to bring their copies of these authors to Pekin, and after giving a great banquet in their honour, he buried alive the professors along with their manuscripts in a deep pit. But Confucius and Mencius still reign supreme. I advocate milder measures, and depend for their adoption on the force of public opinion. The needs of modern life will force schools to adapt themselves to a scientific age. Grammar schools believe themselves to be immortal. Those curious immortals—the Struldbrugs—described by Swift, ultimately regretted their immortality, because they found themselves out of touch, sympathy, and fitness with the centuries in which they lived.

As there is no use clamouring for an instrument of more compass and power until we have made up our mind as to the tune, Professor Huxley, in his evidence before a Parliamentary Committee in 1884, has given a time-table for grammar schools. He demands that out of their forty hours for public and private study, ten should be given to modern languages and history, eight to arithmetic and mathematics, six to science, and two to geography, thus leaving fourteen hours to dead languages. No time table would, however, be suitable to all schools. The great public schools of England will continue to be the gymnasia for the upper classes, and should devote much of their time to classical and literary culture. Even now they introduce into their curriculum subjects unknown to them when the Royal Commission of 1868 reported, though they still accept science with timidity. Unfortunately, the other grammar schools which educate the middle classes look to the higher public schools as a type to which they should conform, although their functions are so different. It is in the interest of the higher public schools that this difference should be recognised, so that while they give an all-round education and expand their curriculum by a freer recognition of the value of science as an educational power in developing the faculties of the upper classes, the schools for the middle classes should adapt themselves to the needs of their exist-

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ence, and not keep up a slavish imitation of schools with a different function. The old classical grammar schools may view these remarks as a direct attack upon them, and so it is in one sense, but it is like the stroke of Ithuriel's spear, which heals while it wounds.

The stock argument against the introduction of modern subjects into grammar schools is that it is better to teach Latin and Greek thoroughly rather than various subjects less completely. But it is true that thoroughness in teaching dead languages is the result of an exclusive system? In 1868 the Royal Commission stated that even in the few great public schools thoroughness was only given to thirty per cent. of the scholars, at the sacrifice of seventy per cent. who got little benefit from the system. Since then the curriculum has been widened and the teaching has improved. I question the soundness of the principle that it is better to limit the attention of the pupils mainly to Latin and Greek, highly as I value their educational power to a certain order of minds. As in biology the bodily development of animals is from the general to the special, so is it in the mental development of man. In the school a boy should be aided to discover the class of knowledge that is best suited for his mental capacities, so that, in the upper forms of the school and in the university, knowledge may be specialised in order to cultivate the powers of the man to their fullest extent. Shakspeare's educational formula may not be altogether true, but it contains a broad basis of truth—

"No profit goes, where is no pleasure ta'en;
In brief, sir, study what you most affect."

The comparative failure of the modern side of school education arises from constituting it out of the boys who are looked upon as classical asses. Milton pointed out that in all schools there are boys to whom the dead languages are "like thorns and thistles," which form a poor nourishment even for asses. If teachers looked upon these classical asses as beings who might receive mental nurture according to their nature, much higher results would follow the bifurcation of our schools. Saul went out to look for asses and he found a kingdom. Surely this fact is more encouraging than the example of Gideon, who "took thorns of the wilderness and briars, and with these he *taught* the men of Succoth."* The adaptation of public schools to a scientific age does not involve a contest as to whether science or classics shall prevail, for both are indispensable to true education. The real question is whether schools will undertake the duty of moulding the minds of boys according to their mental varieties. Classics, from their structural perfection and power of awakening dormant faculties, have claims to precedence in education, but they have none to a practical monopoly. It is by claiming the latter that teachers sacrifice mental receptivity to a Procrustean uniformity.

The universities are changing their traditions more rapidly than the schools. The *via antiqua* which leads to them is still broad, though a *via moderna*, with branching avenues, is also open to their honours and emoluments. Physical science, which was once neglected, is now encouraged at the universities. As to the seventy per cent. of boys who leave schools for life work without going through the universities, are there no growing signs of discontent which must force a change? The Civil Service, the learned professions, as well as the army and navy, are now barred by examinations. Do the boys of our public schools easily leap over the bars, although some of them have lately been lowered so as to suit the schools? So difficult are these bars to scholars that crammers take them in hand before they attempt the leap; and this occurs in spite of the large value attached to the dead languages and the small value placed on modern subjects. Thus, in the Indian Civil Service examinations, 800 marks as a maximum are assigned to Latin, 600 to Greek, 500 to chemistry, and 300 to each of the other physical sciences. But if we take the average working of the system for the last four years, we find that while sixty-eight per cent. of the maximum were given to candidates in Greek and Latin, only forty-five per cent. were accorded to candidates in chemistry, and but thirty per cent. to the other physical sciences. Schools sending up boys for competition naturally shun subjects which are dealt with so hardly and so heavily handicapped by the State.

Passing from learned or public professions to commerce, how is it that in our great commercial centres, foreigners—German, Swiss, Dutch, and even Greeks—push aside our English youth and take the places of profit which belong to them by national inheritance? How is it that in our colonies, like those in South Africa, German enterprise is pushing aside English incapacity? How is it that we find whole branches of manufactures, when they depend on scientific knowledge, passing away from this country, in which they originated, in order to engraft themselves abroad, although their decaying roots remain at home?† The answer to these questions is that our systems of education are still too narrow for the increasing struggle of life.

Faraday, who had no narrow views in regard to education, deplored the future of our youth in the competition of the world, because, as he said with sadness, "our schoolboys, when they come out of school, are ignorant of their ignorance at the end of all that education."

The opponents of science education allege that it is not adapted for mental development, because scientific facts are often disjointed, and exercise only the memory. Those who argue thus do not know what science is. No doubt an ignorant or half-informed teacher may present science as an accumulation of unconnected facts. At all times and in all subjects there are teachers without æsthetical or philosophical capacity—men who can only see carbonate of lime in a statue by Phidias or Praxiteles; who cannot survey zoology on account of its millions of species, or botany because of its 130,000 distinct plants; men who can look at trees without getting a conception of a forest, and cannot distinguish a stately edifice from its bricks. To teach in that fashion is like going to the tree of science with its glorious fruit in order to pick up a handful of the dry fallen leaves from the ground. It is, however, true that as science teaching has had less lengthened experience than that of literature, its methods of instruction are not so matured. Scientific and literary teaching have different methods; for while the teacher of literature rests on authority and on books for his guidance, the teacher of science discards authority and depends on facts at first hand, and on the book of Nature for their interpretation. Natural science more and more resolves itself into the teaching of the laboratory. In this way it can be used as a powerful means of quickening observation, and of creating a faculty of induction after the manner of Zadig, the Babylonian described by Voltaire. Thus facts become surrounded by scientific conceptions, and are subordinated to order and law.

It is not those who desire to unite literature with science who degrade education; the degradation is the consequence of the refusal. A violent reaction—too violent to be wise—has lately taken place against classical education in France, where their own vernacular occupies the position of dead languages, while Latin and science are given the same time in the curriculum. In England manufacturers cry out for technical education, in which classical culture shall be excluded. In the schools of the middle classes science rather than technics is needed, because, when the seeds of science are sown, technics as its fruit will appear at the appointed time. Epictetus was wise when he told us to observe that though sheep eat grass, it is not grass but wool that grows on their backs. Should, however, our grammar schools persist in their refusal to adapt themselves to the needs of a scientific age, England must follow the example of other European nations and found new modern schools in competition with them. For, as Huxley has put it, we cannot continue in this age "of full modern artillery to turn out our boys to do battle in it equipped only with the sword and shield of an ancient gladiator." In a scientific and keenly competitive age an exclusive education in the dead languages is a perplexing anomaly. The flowers of literature should be cultivated and gathered, though it is not wise to send men into our fields of industry to gather the harvest when they have been taught only to cull the poppies and to push aside the wheat.

IV. *Science and the Universities.*

The State has always felt bound to alter and improve universities, even when their endowments are so large as to render it unnecessary to support them by public funds. When universities are poor, Parliament gives aid to them from imperial taxation. In this country that aid has been given with a very sparing hand. Thus the universities and colleges of Ireland have received about £30,000 annually, and the same sum has been granted to the four universities of Scotland. Compared with imperial aid to foreign universities such sums are small. A single German university, like Strasburg or Leipsic, receives above £40,000 annually, or £10,000 more than the whole colleges of Ireland or of Scotland. Strasburg, for instance, has had her university and its library rebuilt at a cost of £711,000, and receives an annual subscription of £43,000. In rebuilding the university of Strasburg eight laboratories have been provided, so as to equip it fully with the modern requirements for teaching and research.* Prussia, the most economical nation in the world, spends £391,000 yearly out of taxation on her universities.

The recent action of France is still more remarkable. After the Franco-German War the Institute of France discussed the important question:—"Pourquoi la France n'a pas trouvé d'hommes supérieurs au moment du péril?" The general answer was because France had allowed university education to sink to a low ebb. Before the great Revolution France had twenty-three autonomous universities in the provinces. Napoleon desired to found one great university at Paris, and he crushed out the others with the hand of a despot, and remodelled the last with the instincts of a drill sergeant. The central university sank so low that in 1868 it is said that only £8,000 were spent for true academic purposes. Startled by the intellectual sterility shown in the war, France has made gigantic efforts to retrieve her position, and has rebuilt the provincial colleges at a cost of £3,280,000, while her annual budget for their support now reaches half a million of pounds. In order to open these provincial colleges to the best talent of France, more than 500 scholarships have been founded at an annual cost of £30,000. France now recognises that it is not by the number of men under arms that she can compete with her great neighbour Germany, so she has determined to equal her in intellect. You will understand why it is that Germany was obliged, even if she had not been willing, to spend such large sums in order to equip the university of her conquered provinces, Alsace-Lorraine. France and Germany are fully aware that science is the source of wealth and power, and that the only way of advancing it is to encourage universities to make researches and to spread existing knowledge through the community. Other European nations are advancing on the same lines. Switzerland is a remarkable illustration of how a country can compensate itself for its natural disadvantages by a scientific education of its people. Switzerland contains neither coal nor the ordinary raw materials of industry, and is separated from other countries which might supply them by mountain barriers. Yet, by a singularly good system of graded schools, and by the great technical college of Zurich, she has become a prosperous manufacturing country. In Great Britain, we have nothing comparable to this technical college, either in magnitude or efficiency. Belgium is reorganising its universities, and the State has freed the localities from the charge of buildings, and it will in future equip the universities with efficient teaching resources out of public taxation. Holland, with a population of 4,000,000 and a small revenue of £9,000,000, spends £136,000 on her four universities. Contrast this liberality of foreign countries in the

* Judges viii. 16.

† See Dr. Perkins' address to the Soc. Chem. Industry. *Nature*, Aug. 6, 1855, p. 333.

* The cost of these laboratories has been as follows:—Chemical Institute, £35,000; Physical Institute, £28,000; Botanical Institute, £26,000; Observatory, £25,000; Anatomy, £42,000; Clinical Surgery, £26,000; Physiological Chemistry, £16,000; Physiological Institute, £13,900.

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promotion of higher instruction with the action of our own country. Scotland, like Holland, has four universities, and is not very different from it in population, but it only receives £30,000 from the State. By a special clause in the Scotch Universities Bill the Government asked Parliament to declare that under no circumstances should the Parliamentary grant be ever increased above £40,000. According to the views of the British Treasury there is a finality in science and in expanding knowledge.

The wealthy Universities of Oxford and Cambridge are gradually constructing laboratories for science. The merchant princes of Manchester have equipped their new Victoria University with similar laboratories. Edinburgh and Glasgow Universities have also done so, partly at the cost of Government and largely by private subscriptions. The poorer Universities of Aberdeen and St. Andrews are still inefficiently provided with the modern appliances for teaching science.

London has one small Government college and two chartered colleges, but is wholly destitute of a teaching university. It would excite great astonishment at the Treasury if we were to make the modest request that the great metropolis, with a population of four millions, should be put into as efficient academical position as the town of Strasburg, with 104,000 inhabitants, by receiving, as that town does, £43,000 annually for academic instruction, and £700,000 for University buildings. Still, the amazing anomaly that London has no teaching university must ere long cease.

It is a comforting fact that, in spite of the indifference of Parliament, the large towns of the kingdom are showing their sense of the need of higher education. Manchester has already its university. Nottingham, Birmingham, Leeds, and Bristol have colleges more or less complete. Liverpool converts a disused lunatic asylum into a college for sane people. Cardiff rents an infirmary for a collegiate building. Dundee, by private benefaction, rears a Baxter College with larger ambitions. All these are healthy signs that the public are determined to have advanced science teaching, but the resources of the institutions are altogether inadequate to the end in view. Even in the few cases where the laboratories are efficient for teaching purposes, they are inefficient as laboratories for research. Under these circumstances the Royal Commission on Science advocates special Government laboratories for research. Such laboratories, supported by public money, are as legitimate subjects for expenditure as galleries for pictures or sculpture; but I think that they would not be successful, and would injure science if they failed. It would be safer in the meantime if the State assisted universities or well-established colleges to found laboratories of research under their own care. Even such a proposal shocks our Chancellor of the Exchequer, who tells us that this country is burdened with public debt, and has ironclads to build and arsenals to provide. Nevertheless our wealth is proportionally much greater than that of foreign States, which are competing with so much vigour in the promotion of higher education. They deem such expenditure to be true economy, and do not allow their huge standing armies to be an apology for keeping their people backwards in the march of knowledge. France, which in the last ten years has been spending a million annually on university education, had a war indemnity to pay, and competes successfully with this country in ironclads. Either all foreign States are strangely deceived in their belief that the competition of the world has become a competition of intellect, or we are marvellously unobservent of the change which is passing over Europe in the higher education of the people. Preparations for war will not ensure to us the blessings and security of an enlightened peace. Protective expenditure may be wise, though productive expenditure is wiser.

"Were half the powers which fill the world with terror,
Were half the wealth bestowed on camps and courts,
Given to redeem the human mind from error—
There were no need of arsenals and forts."

Universities are not mere storehouses of knowledge; they are also conservatories for its cultivation. In Mexico there is a species of ant which sets apart some of its individuals to act as honey-jars by monstrously extending their abdomens to store the precious fluid till it is wanted by the community. Professors in a university have a higher function, because they ought to make new honey as well as to store it. The widening of the bounds of knowledge, literary or scientific, is the crowning glory of university life. Germany unites the functions of teaching and research in the universities, while France keeps them in separate institutions. The former system is best adapted to our habits, but its condition for success is that our science chairs should be greatly increased so that teachers should not be wholly absorbed in the duties of instruction. Germany subdivides the sciences into various chairs, and gives to the professors special laboratories. It also makes it a condition for the higher honours of a university that the candidates shall give proofs of their ability to make original researches. Under such a system, teaching and investigation are not incompatible. In the evidence before the Science Commission many opinions were given that scientific men engaged in research should not be burdened with the duties of education, and there is much to be said in support of this view when a single professor for the whole range of a physical science is its only representative in a university. But I hope that such a system will not long continue, for if it do we must occupy a very inferior position as a nation in the intellectual competition of Europe. Research and education in limited branches of higher knowledge are not incompatible. It is true that Galileo complained of the burden imposed upon him by his numerous astronomical pupils, though few other philosophers have echoed this complaint. Newton, who produced order in worlds, and Dalton, who brought atoms under the reign of order and number, rejoiced in their pupils. Lalande spread astronomers, as Liebig spread chemists and Johannes Müller biologists, all over the world. Laplace, La Grange, Dulong, Gay Lussac, Berthollet, and Dumas were professors as well as discoverers in France. In England our discoverers have generally been teachers. In fact I recollect only three notable examples of men who were not—Boyle, Cavendish, and Joule. It was so in ancient as well as in modern times, for Plato and Aristotle taught and philosophised. If you do not make the investigator a schoolmaster, as Dalton was, and as practically our professors are at the present time, with the duty of teaching all branches of their sciences, the mere elementary truths as well as the highest generalisations being compressed into a course, it is well that they should be brought into contact with the world in which they live, so as to know its wants and aspirations. They could then quicken the pregnant minds around them, and extend to others their own power and love of research. Goethe had a fine perception of this when he wrote—

Wer in der Weltgeschichte lebt,
Wer in die Zeiten schaut, und strebt,
Nur der ist werth, zu sprechen und zu dichten.

Our universities are still far from the attainment of a proper combination of their resources between teaching and research. Even Oxford and Cambridge, which have done so much in recent years in the equipment of laboratories and in adding to their scientific staff, are still far behind a second-class German university. The professional faculties of the English universities are growing, and will diffuse a greater taste for science among their students, though they may absorb the time of the limited professoriate so as to prevent it advancing the boundaries of knowledge. Professional faculties are absolutely essential to the existence of universities in poor countries like Scotland and Ireland. This has been the case from the early days of the Bologna University up to the present time. Originally universities arose not by mere bulls of popes, but as a response to the strong desire of the professional classes to dignify their crafts by real knowledge. If their education had been limited to mere technical schools like the Medical School of Salerno which flourished in the eleventh century, length but not breadth would have been given to education. So the universities wisely joined culture to the professional sciences. Poor countries like Scotland and Ireland must have their academic systems based on the professional faculties, although wealthy universities like Oxford and Cambridge may continue to have them as mere supplements to a more general education. A greater liberality of support on the part of the State in the establishment of chairs of science, for the sake of science and not merely for the teaching of the professions, would enable the poorer universities to take their part in the advancement of knowledge.

I have already alluded to the foundation of new colleges in different parts of the kingdom. Owens College has worthily developed into the Victoria University. Formerly she depended for degrees on the University of London. No longer will she be like a moon reflecting cold and sickly rays from a distant luminary, for in future she will be a sun, a centre of intelligence, warming and illuminating the regions around her. The other colleges which have formed themselves in large manufacturing districts are remarkable expressions from them that science must be promoted. Including the colleges of a high class, such as University College and King's College in London, and the three Queen's Colleges in Ireland, the aggregate attendance of students in colleges without university rank is between nine and ten thousand, whilst that of the universities is fifteen thousand. No doubt some of the provincial colleges require considerable improvement in their teaching methods; sometimes they unwisely aim at a full university curriculum when it would be better for them to act as faculties. Still they are all growing in the spirit of self-help, and some of them are destined, like Owens College, to develop into universities. This is not a subject of alarm to lovers of education, while it is one of hope and encouragement to the great centres of industry. There are too few autonomous universities in England in proportion to its population. While Scotland, with a population of 3¾ millions, has four universities with 6,500 students, England, with 26 millions of people, has only the same number of teaching universities with 6,000 students. Unless English colleges have such ambition, they may be turned into mere mills to grind out material for examinations and competitions. Higher colleges should always hold before students that knowledge, for its own sake, is the only object worthy of reverence. Beyond college life there is a land of research flowing with milk and honey for those who know how to cultivate it. Colleges should at least show a Pisgah view of this Land of Promise, which stretches far beyond the Jordan of examinations and competitions.

V. *Science and Industry.*

In the popular mind the value of science is measured by its applications to the useful purposes of life. It is no doubt true that science wears a beautiful aspect when she confers practical benefits upon man. But truer relations of science to industry are implied in Greek mythology. Vulcan, the god of industry, wooed science, in the form of Minerva, with a passionate love, but the chaste goddess never married, although she conferred upon mankind nearly as many arts as Prometheus, who, like other inventors, saw civilisation progressing by their use while he lay groaning in want on Mount Caucasus. The rapid development of industry in modern days depends on the applications of scientific knowledge, while its slower growth in former times was due to experiments being made by trial and error in order to gratify the needs of man. Then an experiment was less a questioning of Nature than an exercise on the mind of the experimentalist. For a true questioning of Nature only arises when intellectual conceptions of the causes of phenomena attach themselves to ascertained facts as well as to their natural environments. Much real science had at one time accumulated in Egypt, Greece, Rome, and Arabia, though it became obscured by the intellectual darkness which spread over Europe like a pall for many centuries. The mental results of Greek science, filtered through the Romans and Arabians, gradually fertilised the soil of Europe. Even in ages which are deemed to be dark and unprolific, substantial though slow progress was made. By the end of the fifteenth century the mathematics of the Alexandrian school had become

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the possession of Western Europe; Arabic numerals, algebra, trigonometry, decimal reckoning, and an improved calendar having been added to its stock of knowledge. The old discoveries of Democritus and Archimedes in physics, and of Hipparchus and Ptolemy in astronomy, were producing their natural developments, though with great slowness. Many manufactures, growing chiefly by experience, and occasionally lightened up by glimmerings of science throughout the prevailing darkness, had arisen before the sixteenth century. A knowledge of the properties of bodies, though scarcely of their relations to each other, came through the labours of the alchemists, who had a mighty impulse to work, for by the philosopher's stone, often not larger than half a rape-seed, they hoped to attain the three sensuous conditions of human enjoyment, gold, health, and immortality. By the end of the fifteenth century many important manufactures were founded by empirical experiment, with only the uncertain guidance of science. Among these were the compass, printing, paper, gunpowder, guns, watches, forks, knitting-needles, horseshoes, bells, woodcutting and copper engraving, wire-drawing, steel, table glass, spectacles, microscopes, glass mirrors backed by amalgams of tin and lead, windmills, crushing and saw mills. These important manufactures arose from an increased knowlege of facts, around which scientific conceptions were slowly concreting. Aristotle defines this as science when he says, "Art begins when, from a great number of experiences, one general conception is formed which will embrace all similar cases." Such conceptions are formed only when culture develops the human mind and compels it to give a rational account of the world in which man lives, and of the objects in and around it, as well as of the phenomena which govern their action and evolution. Though the accumulation of facts is indispensable to the growth of science, a thousand facts are of less value to human progress than is a single one when it is scientifically comprehended, for it then becomes generalised in all similar cases. Isolated facts may be viewed as the dust of science. The dust which floats in the atmosphere is to the common observer mere incoherent matter in a wrong place, while to the man of science it is all-important when the rays of heat and light act upon its floating particles. It is by them that clouds and rains are influenced; it is by their selective influence on the solar waves that the blue of the heavens and the beauteous colours of the sky glorify all Nature. So, also, ascertained through isolated facts, forming the dust of science, become the reflecting media of the light of knowledge, and cause all Nature to assume a new aspect. It is with the light of knowledge that we are enabled to question Nature through direct experiment. The hypothesis or theory which induces us to put the experimental question may be right or wrong; still, *prudens questio dimidium scientiæ est*—it is half-way to knowledge when you know what you have to inquire. Davy described hypothesis as the mere scaffolding of science, useful to build up true knowledge, but capable of being put up or taken down at pleasure. Undoubtedly a theory is only temporary, and the reason is, as Bacon has said, that the man of science "loveth truth more than his theory." The changing theories which the world despises are the leaves of the tree of science drawing nutriment to the parent stems, and enabling it to put forth new branches and to produce fruit; and though the leaves fall and decay, the vary products of decay nourish the roots of the tree and reappear in the new leaves or theories which succeed.

When the questioning of Nature by intelligent experiment has raised a system of science, then those men who desire to apply it to industrial inventions proceed by the same methods to make rapid progress in the arts. They also must have means to compel Nature to reveal her secrets. Æneas succeeded in his great enterprise by plucking a golden branch from the tree of science. Armed with this even dread Charon dared not refuse a passage across the Styx; and the gate of the Elysian fields was unbarred when he hung the branch on its portal. Then new aspects of Nature were revealed—

"Another sun and stars they know
That shine like ours, but shine below."

It is by carrying such a golden branch from the tree of science that inventors are able to advance the arts. In illustration of how slowly at first and how rapidly afterwards science and its applications arise, I will take only two out of thousands of examples which lie ready to my hand. One of the most familiar instances is air, for that surely should have been soon understood if man's unaided senses are sufficient for knowledge. Air has been under the notice of mankind ever since the first man drew his first breath. It meets him at every turn; it fans him with gentle breezes, and it buffets him with storms. And yet it is certain that this familiar object—air—is very imperfectly understood up to the present time. We now know by recent researches that air can be liquified by pressure and cold; but as a child still looks upon air as nothing, so did man in his early state. A vessel with air was deemed to be empty. But man, as soon as he began to speculate, felt the importance of air, and deemed it to be a soul of the world upon which the respiration of man and the god-like quality of fire depended. Yet a really intelligent conception of these two essential conditions to man's existence—respiration and combustion—was not formed till about a century ago (1775). No doubt long before that time there had been abundant speculations regarding air. Anaximenes, 548 years before Christ, and Diogenes of Apollonia, a century later, studied the properties of air so far as their senses would allow them; so, in fact, did Aristotle. Actual scientific experiments were made on air about the year 1100 by a remarkable Saracen, Alhazen, who ascertained important truths which enabled Galileo, Torricelli, Otto de Guericke, and others at a later period to discover laws leading to important practical applications. Still there was no intelligent conception as to the composition of air until Priestley in 1774 repeated, with the light of science, an empirical observation which Eck de Sulbach had made three hundred years before upon the union of mercury with an ingredient of air and the decomposition of this compound by heat. This experiment now proved that the active element in air is oxygen. From that date our knowledge, derived from an intelligent questioning of air by direct experiments, has gone on by leaps and bounds. The air, which mainly consists of nitrogen and oxygen, is now known to contain carbonic acid, ammonia, nitric acid, ozone, besides hosts of living organisms which have a vast influence for good or evil in the economy of the world. These micro-organisms, the latest contribution to our knowledge of air, perform great analytical functions in organic nature, and are the means of converting much of its potential energy into actual energy. Through their action on dead matter the mutual dependence of plants and animals is secured, so that the air becomes at once the grave of organic death and the cradle of organic life. No doubt the ancients suspected this without being able to prove the dependence. Euripides seems to have seen it deductively when he describes the result of decay:—

"Then that which springs from earth, to earth returns,
And that which draws its being from the sky
Rises again up to the skyey height."

The consequences of the progressive discoveries have added largely to our knowledge of life, and have given a marvellous development to the industrial arts. Combustion and respiration govern a wide range of processes. The economical use of fuel, the growth of plants, the food of animals, the processes of husbandry, the maintenance of public health, the origin and cure of disease, the production of alcoholic drinks, the processes of making vinegar and saltpetre—all these and many other kinds of knowledge have been brought under the dominion of law. No doubt animals respired, fuel burned, plants grew, sugar fermented, before we knew how they depended upon air. But as the knowledge was empirical, it could not be intelligently directed. Now all these processes are ranged in order under a wise economy of Nature, and can be directed to the utilities of life; for it is true, as Swedenborg says, that human "ends always ascend as Nature descends." There is scarcely a large industry in the world which has not received a mighty impulse by the better knowledge of air acquired within a hundred years. If I had time I could show still more strikingly the industrial advantages which have followed from Cavendish's discovery of the composition of water. I wish that I could have done this, because it was Addison who foolishly said, and Paley who as unwisely approved the remark, "that mankind required to know no more about water than the temperature at which it froze and boiled, and the mode of making steam."

When we examine the order of progress in the arts, even before they are illumined by science, their improvements seem to be resultants of three conditions.

1. The substitution of natural forces for brute animal power, as when Hercules used the waters of the Alpheus to cleanse the Augean stables; or when a Kamchadal of Eastern Asia, who has been three years hollowing out a canoe, finds that he can do it in a few hours by fire.

2. The economy of time, as when a calendering machine produces the same gloss to miles of calico that an African savage gives to a few inches by rubbing it with the shell of the snail; or the economy of production, as when steel pens, sold when first introduced at one shilling a piece, are now sold at a penny per dozen; or when steel rails, lately costing £45 per ton, can now be sold at £5.

3. Methods of utilising waste products, or of endowing them with properties which render them of increased value to industry, as when waste-scrap iron and the galls on the oak are converted into ink; or the badly-smelling waste of gasworks is transformed into fragrant essences, brilliant dyes, and fertilising manure; or when the effete matter of animals or old bones is changed into lucifer matches.

All three results are often combined when a single end is obtained—at all events, economy of time and production invariably follows when natural forces substitute brute animal force. In industrial progress the sweat of the brow is lessened by the conceptions of the brain. How exultant is the old Greek poet, Antipator,* when women are relieved of the drudgery of turning the grindstones for the daily supply of corn. "Woman! you have hitherto had to grind corn, let your arms rest for the future. It is no longer for you that the birds announce by their songs the dawn of the morning. Ceres has ordered the *water-nymphs* to move the heavy millstones and perform your labour." Penelope had twelve slaves to grind corn for her small household. During the most prosperous time of Athens it was estimated that there were twenty slaves to each free citizen. Slaves are mere machines, and machines neither invent nor discover. The bondmen of the Jews, the helots of Sparta, the captive slaves of Rome, the serfs of Europe, and uneducated labourers of the present day who are the slaves of ignorance have added nothing to human progress. But as natural forces substitute and become cheaper than slave labour, liberty follows advancing civilisation. Machines require educated superintendence. One shoe factory in Boston by its machines does the work of thirty thousand shoemakers in Paris who have still to go through the weary drudgery of mechanical labour. The steam power of the world, during the last twenty years, has risen from 11½ million to 29 million horse-power, or 152 per cent.

Let me take a single example of how even a petty manufacture improved by the teachings of science affects the comforts and enlarges the resources of mankind. When I was a boy, the only way of obtaining a light was by the tinder box, with its quadruple materials, flint and steel, burnt rags or tinder, and a sulphur match. If everything went well, if the box could be found and the air was dry, a light could be obtained in two minutes; but very often the time occupied was much longer, and the process became a great trial to the serenity of temper. The consequence of this was that a fire or a burning lamp was kept alight through the day. Old Gerard, in his herbal, tells us how certain fungi were used to carry fire from one part of the country to the other. The tinder-box long held its position as a great discovery in the arts. The *Pyxidicula Igniaria* of the Romans appears to have been much the same implement.

* *Analecta Veterum Græcorum*, Epig. 39, Vol. II., p. 119.

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though a little ruder, than the flint and steel which Philip the Good put into the collar of the Golden Fleece in 1429 as a representation of high knowledge in the progress of the arts. It continued to prevail till 1833, when phosphorous matches were introduced, though I have been amused to find that there are a few venerable ancients in London who still stick to the tinder box, and for whom a few shops keep a small supply. Phosphorous was no new discovery, for it had been obtained by an Arabian called Bechel in the eighth century. However, it was forgotten, and was rediscovered by Brandt, who made it out of very stinking materials in 1669. Other discoveries had, however, to be made before it could be used for lucifer matches. The science of combustion was only developed on the discovery of oxygen a century later. Time had to elapse before chemical analysis showed the kind of bodies which could be added to phosphorus so as to make it ignite readily. So it was not till 1833 that matches became a partial success. Intolerably bad they then were, dangerously inflammable, horribly poisonous to the makers and injurious to the lungs of the consumers. It required another discovery by Schrötter in 1845 to change poisonous waxy into innocuous red-brick phosphorous in order that these defects might be remedied, and to give us the safety match of the present day. Now what have these successive discoveries in science done for the nation, in this single manufacture, by an economy of time? If before 1833 we had made the same demands for light that we now do, when we daily consume eight matches per head of the population, the tinder box could have supplied the demand under the most favourable conditions by an expenditure of one quarter of an hour. The lucifer match supplies a light in fifteen seconds on each occasion, or in two minutes for the whole day. Putting these differences into a year, the venerable ancient who still sticks to his tinder box would require to spend ninety hours yearly in the production of light, while the user of lucifer matches spends twelve hours; so that the latter has an economy of seventy-eight hours yearly, or about ten working days. Measured by cost of production at one shilling and sixpence daily, the economy of time represented in money to our population is twenty-six millions of pounds annually. This is a curious instance of the manner in which science leads to economy of time and wealth even in a small manufacture. In larger industries the economy of time and labour produced by the application of scientific discoveries is beyond all measurement. Thus the discovery of latent heat by Black led to the inventions of Watt; while that of the mechanical equivalent of heat by Joule has been the basis of the progressive improvements in the steam engine which enables power to be obtained by a consumption of fuel less than one-fourth the amount used twenty years ago. It may be that the engines of Watt and Stephenson will yield in their turn to more economical motors; still they have already expanded the wealth, resources, and even the territories of England more than all the battles fought by her soldiers or all the treaties negotiated by her diplomatists.

The coal which has hitherto been the chief source of power probably represents the product of five or six million years during which the sun shone upon the plants of the carboniferous period, and stored up its energy in this convenient form. But we are using this conserved force wastefully and prodigally; for although horse-power in steam engines has so largely increased since 1864, two men only now produce what three men did at that date. It is only three hundred years since we became a manufacturing country. According to Professor Dewar, in less than two hundred years more the coal of this country will be wholly exhausted, and in half that time will be difficult to procure. Our not very distant descendants will have to face the problem, What will be the condition of England without coal? The answer to that question depends upon the intellectual development of the nation at that time. The value of the intellectual factor of production is continually increasing; while the values of raw material and fuel are lessening factors. It may be that when the dreaded time of exhausted fuel has arrived, its importation from other coal-fields, such as those of New South Wales, will be so easy and cheap that the increased technical education of our operatives may largely overbalance the disadvantages of increased cost in fuel. But this supposes that future Governments in England will have more enlightened views as to the value of science than past Governments have possessed.

Industrial applications are but the overflowing of science welling over from the fulness of its measure. Few would ask now, as was constantly done a few years ago, "What is the use of an abstract discovery in science?" Faraday once answered this question by another, "What is the use of a baby?" Yet round that baby centre all the hopes and sentiments of his parents, and even the interests of the State, which interferes in its upbringing, so as to insure it being a capable citizen. The processes of mind which produce a discovery or an invention are rarely associated in the same person, for while the discoverer seeks to explain causes and the relations of phenomena, the inventor aims at producing new effects, or at least of obtaining them in a novel and efficient way. In this the inventor may sometimes succeed without much knowledge of science, though his labours are infinitely more productive when he understands the causes of the effects which he desires to produce.

A nation in its industrial progress, when the competition of the world is keen, cannot stand still. Three conditions only are possible for it. It may go forward, retrograde, or perish. Its extinction as a great nation follows its neglect of higher education, for, as described in the proverb of Solomon, "They that hate instruction love death." In sociology, as in biology, there are three states. The first of balance, when things grow neither better nor worse; the second that of elaboration or evolution, as we see it when animals adapt themselves to their environments; and third, that of degeneration, when they rapidly lose the ground they have made. For a nation, a state of balance is only possible in the early stage of its existence, but it is impossible when its environments are constantly changing.

The possession of the raw materials of industry and the existence of a surplus population are important factors for the growth of manufactures in the early history of a nation, but afterwards they are bound up with another factor—the application of intellect to their development. England could not be called a manufacturing nation till the Elizabethan age. No doubt coal, iron, and wool were in abundance, though in the reign of the Plantagenets, they produced little prosperity. Wool was sent to Flanders to be manufactured, for England then stood to Holland as Australia now does to Yorkshire. The political crimes of Spain from the reign of Ferdinand and Isabella to that of Philip III. destroyed it as a great manufacturing nation, and indirectly led to England taking its position. Spain, through the activity and science of the Arabian intellect, had acquired many important industries. The Moors and the Moriscoes, who had been in Spain for a period as long as from the Norman Conquest of this country to the present date, were banished, and with them departed the intellect of Spain. Then the invasion of the Low Countries by Philip II. drove the Flemish manufacturers to England, while the French persecution of the Huguenots added new manufacturing experience, and with them came the industries of cotton, wool, and silk. Cotton mixed with linen and wool became freely used, but it was only from 1738 to the end of the the century that the inventions of Wyatt, Arkwright, Hargreaves, Crompton, and Cartwright started the wonderful modern development. The raw cotton was imported from India or America, but that fact as regards cost was a small factor in comparison with the intellect required to convert it into a utility. Science has in the last hundred years altered altogether the old conditions of industrial competition. She has taught the rigid metals to convey and record our thoughts even to the most distant lands, and, within less limits, to reproduce our speech. This marvellous application of electricity has diminished the cares and responsibilities of Governments, while it has at the same time altered the whole practice of commerce. To England steam and electricity have been of incalculable advantage. The ocean, which once made the country insular and isolated, is now the very life-blood of England and of the greater England beyond the seas. As in the human body the blood bathes all its parts, and through its travelling corpuscles carries force to all its members, so in the body politic of England and its pelasgic extensions, steam has become the circulatory and electricity the nervous system. The colonies, being young countries, value their raw materials as their chief source of wealth. When they become older they will discover it is not in these, but in the culture of scientific intellect, that their future prosperity depends. Older nations recognise this as the law of progress more than we do; or, as Jules Simon tersely puts it—"That nation which most educates her people will become the greatest nation, if not to-day, certainly to-morrow." Higher education is the condition of higher prosperity, and the nation which neglects to develop the intellectual factor of production must degenerate, for it cannot stand still. If we felt compelled to adopt the test of science given to Comte, that its value must be measured by fecundity, it might be prudent to claim industrial inventions as the immediate fruit of the tree of science, though only fruit which the prolific tree has shed. But the test is untrue in the sense indicated, or rather the fruit, according to the simile of Bacon, is like the golden apples which Aphrodite gave to the suitor of Atalanta, who lagged in her course by stooping to pick them up, and so lost the race. The true cultivators of the tree of science must seek their own reward by seeing it flourish, and let others devote their attention to the possible practical advantages which may result from their labours.

There is, however, one intimate connection between science and industry which I hope will be more intimate as scientific education becomes more prevalent in our schools and universities. Abstract science depends on the support of men of leisure, either themselves possessing or having provided for them the means of living without entering into the pursuits of active industry. The pursuit of science requires a superfluity of wealth in a community beyond the needs of ordinary life. Such superfluity is also necessary for art, though a picture or a statue is a saleable commodity, while an abstract discovery in science has no immediate or, as regards the discoverer, proximate commercial value. In Greece, when philosophical and scientific speculation was at its highest point, and when education was conducted in its own vernacular, and not through dead languages, science, industry, and commerce were actively prosperous. Corinth carried on the manufactures of Birmingham and Sheffield, while Athens combined those of Leeds, Staffordshire, and London, for it had woollen manufactures, potteries, gold and silver work, as well as shipbuilding. Their philosophers were the sons of burghers, and sometimes carried on the trades of their fathers. Thales was a travelling oil merchant, who brought back science as well as oil from Egypt. Solon and his great descendant Plato, as well as Zeno, were men of commerce. Socrates was a stone mason, Thucydides a gold miner, Aristotle kept a druggist's shop until Alexander endowed him with the wealth of Asia. All but Socrates had a superfluity of wealth, and he was supported by that of others. Now, if our universities and schools created that love of science which a broad education would surely inspire, our men of riches and leisure who advance the boundaries of scientific knowledge could not be counted on the fingers as they now are, when we think of Boyle, Cavendish, Napier, Lyell, Murchison, and Darwin, but would be as numerous as our statesmen and orators. Statesmen, without a following of the people who share their views and back their work, would be feeble indeed. But while England has never lacked leaders in science, they have too few followers to risk a rapid march. We might create an army to support our generals in science, as Germany has done, and as France is now doing, if education in this country would only mould itself to the needs of a scientific age. It is with this feeling that Horace Mann wrote:—"The action of the mind is like the action of fire; one billet of wood will hardly burn alone, though as dry as the sun and north west wind can make it, and though placed in a current of air; ten such billets will burn well together, but a hundred will create a heat fifty times as intense as ten—will make a current of air to fan their own flame, and consume even greenness itself."

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VI.—*Abstract Science the Condition for Progress.*

The subject of my address has been the relations of science to the public weal. That is a very old subject to select for the year 1885. I began it by quoting the words of an illustrious prince, the consort of our Queen, who addressed us on the same subject from this platform twenty-six years ago. But he was not the first prince who saw how closely science is bound up with the welfare of States. Ali, the son-in-law of Mahomed, the fourth successor to the Caliphate, urged upon his followers that men of science and their disciples give security to human progress. Ali loved to say, "Eminence in science is the highest of honours," and "He dies not who gives life to learning." In addressing you upon texts such as these, my purpose was to show how unwise it is for England to lag in the onward march of science, when most other European Powers are using the resources of their States to promote higher education and to advance the boundaries of knowledge. English Governments alone fail to grasp the fact that the competition of the world has become a competition in intellect. Much of this indifference is due to our systems of education. I have ill fulfilled my purpose if, in claiming for science a larger share in public education, I have in any way depreciated literature, art, or philosophy, for every subject which adds to culture aids in human development. I only contend that in public education there should be a free play to the scientific faculty, so that the youths who possess it should learn the richness of their possession during the educative process. The same faculties which make a man great in any walk of life—strong love of truth, high imagination tempered by judgment, a vivid memory which can co-ordinate other facts with those under immediate consideration—all these are qualities which the poet, the philosopher, the man of literature, and the man of science equally require, and should cultivate through all parts of their education as well as in their future careers. My contention is that science should not be practically shut out from the view of a youth while his education is in progress, for the public weal requires that a large number of scientific men should belong to the community. This is necessary because science has impressed its character upon the age in which we live, and as science is not stationary but progressive, men are required to advance its boundaries, acting as pioneers in the onward march of States. Human progress is so identified with scientific thought, both in its conception and realisation, that it seems as if they were alternative terms in the history of civilisation. In literature, and even in art, a standard of excellence has been attained which we are content to imitate because we have been unable to surpass. But there is no such standard in science. Formerly, when the dark cloud was being dissipated which had obscured the learning of Greece and Rome, the diffusion of literature or the discovery of lost authors had a marked influence on advancing civilisation. Now, a Chrysoloras might teach Greek in the Italian universities without hastening sensibly the onward march of Italy; a Poggio might discover copies of Lucretius and Quintilian without exercising a tithe of the influence on modern life that an invention by Stephenson or Wheatstone would produce. Nevertheless, the divorce of culture and science, which the present state of education in this country tends to produce, is deeply to be deplored, because a cultured intelligence adds greatly to the development of the scientific faculty. My argument is that no amount of learning without science suffices in the present state of the world to put us in a position which will enable England to keep ahead or even on a level with foreign nations as regards knowledge and its applications to the utilities of life. Take the example of any man of learning, and see how soon the direct consequences resulting from it disappear in the life of a nation, while the discoveries of a man of science remain productive amid all the shocks of empire. As I am in Aberdeen I remember that the learned Dutchman Erasmus was introduced to England by the encouragement which he received from Hector Boece, the Principal of King's College in this University. Yet even in the case of Erasmus—who taught Greek at Cambridge and did so much for the revival of classical literature as well as in the promotion of spiritual freedom—how little has civilisation to ascribe to him in comparison with the discoveries of two other Cambridge men, Newton and Cavendish. The discoveries of Newton will influence the destinies of mankind to the end of the world. When he established the laws by which the motions of the great masses of matter in the universe are governed, he conferred an incalculable benefit upon the intellectual development of the human race. No great discovery flashes upon the world at once, and therefore Pope's lines on Newton are only a poetic fancy:—

"Nature and Nature's laws lay hid in night,
God said, 'Let Newton be,' and all was light."

No doubt the road upon which he travelled had been long in preparation by other men. The exact observations of Tycho Brahe, coupled with the discoveries of Copernicus, Kepler, and Galileo, had already broken down the authority of Aristotle and weakened that of the Church. But though the conceptions of the universe were thus broadened, mankind had not yet rid themselves of the idea that the powers of the universe were still regulated by spirits or special providences. Even Kepler moved the planets by spirits, and it took some time to knock these celestial steersmen on the head. Descartes, who really did so much by his writings to force the conclusion that the planetary movements should be dealt with as an ordinary problem in mechanics, looked upon the universe as a machine, the wheels of which were kept in motion by the unceasing exercise of a Divine power. Yet such theories were only an attempt to regulate the universe by celestial intelligences like our own, and by standards within our reach. It required the discovery of an all-pervading law, universal throughout all space, to enlarge the thoughts of men, and one which, while it widened the conceptions of the universe, reduced the earth and solar system to true dimensions. It is by the investigation of the finite on all sides that we obtain a higher conception of the infinite—

"Willst du ins Unendliche schreiten,
Geh nur im Endlichen nach allen Seiten.'

Ecclesiastical authority had been already undermined by earnest inquirers such as Wycliffe and Huss before Luther shook the pillars of the Vatican. They were removers of abuses, but were confined within the circles of their own beliefs. Newton's discovery cast men's minds into an entirely new mould, and levelled many barriers to human progress. This intellectual result was vastly more important than the practical advantages of the discovery. It is true that navigation and commerce mightily benefited by our better knowledge of the motions of the heavenly bodies. Still, these benefits to humanity are incomparably less in the history of progress than the expansion of the human intellect which followed the withdrawal of the cramps that confined it. Truth was now able to discard authority, and marched forward without hindrance. Before this point was reached Bruno had been burned, Galileo had abjured, and both Copernicus and Descartes had kept back their writings for fear of offending the Church.

The recent acceptance of evolution in biology has had a like effect in producing a far profounder intellectual change in human thought than any mere impulse of industrial development. Already its application to sociology and education is recognised, but that is of less import to human progress than the broadening of our views of Nature.

Abstract discovery in science is, then, the true foundation upon which the superstructure of modern civilisation is built; and the man who would take part in it should study science, and if he can advance it for its own sake and not for its applications. Ignorance may walk in the path lighted by advancing knowledge, but she is unable to follow when science passes her, for, like the foolish virgin, she has no oil in her lamp.

An established truth in science is like the constitution of an atom in matter—something so fixed in the order of things that it has become independent of further dangers in the struggle for existence. The sum of such truths forms the intellectual treasure which descends to each generation in hereditary succession. Though the discoverer of a new truth is a benefactor to humanity, he can give little to futurity in comparison with the wealth of knowledge which he inherited from the past. We, in our generation, should appreciate and use our great possessions—

"For me your tributary stores combine,
Creation's heir; the world, the world is mine."

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Sept. 9.		Business Done Week Ending Sept. 9. Highest.		Lowest.	
Anglo-American	30½,	31½	.....	30¾	.....	—
Do. Preferred	51½,	52½	.....	52½	.....	—
Do. Deferred	8,	9	.....	8½	.....	—
Brazilian Submarine	11,	11½	.....	11½	.....	11½
Cuba	12,	12½	.....	—	.....	—
Do. Preference	18,	19	.....	—	.....	—
Direct Spanish	1½,	2	.....	—	.....	—
Do. Preference	12,	12½	.....	—	.....	—
Direct United States Cable	8¾,	9¼	.....	9¼	.....	—
Eastern Telegraph	11½,	11⅝	.....	11 11-16	.....	11 3-16
Do. 6 per Cent. Preference	13½,	13¾	.....	13 11-16	.....	13⅝
Do. 5 per Cent. Debentures, 1899	105,	108	.....	106	.....	—
Eastern Extension	12⅛,	12¼	.....	12⅜	.....	12⅛
German Union	9¼,	9⅜	.....	—	.....	—
Globe Telegraph and Trust	6⅜,	7⅛	.....	7 3-16	.....	7 1-16
Do. Preference	12⅜,	13⅛	.....	13⅛	.....	12 15-16
Great Northern	13⅜,	14⅛	.....	14⅛	.....	14
Indo-European	31,	32	.....	31	.....	—
Reuter's	7½,	8	.....	—	.....	—
Submarine	190	200	.....	188	.....	—
West India and Panama	¾,	1	.....	—	.....	—
Do. 1st Preference	8½,	8¾	.....	8⅝	.....	—
Western Brazilian	6,	6¼	.....	6 3-16	.....	6
Western Union 7 per Cent. 1st Mortgage	120,	124	.....	120½	.....	—
Do. 6 per Cent. Sterling Bonds	100,	102	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	11-16,	13-16	.....	11-16	.....	—
Oriental	⅛,	¼	.....	—	.....	—
United Telephone	11¾,	12⅛	.....	12	.....	11 11-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	.....	—	.....	—
Do. (fully paid)	2¾,	3⅛	.....	3	.....	2¾
Hammond Light (£3 15s. paid)	1-16	3-16	.....	—	.....	—
Swan	⅛,	¼	.....	—	.....	—
Maxim-Weston	⅛,	¼	.....	3-16	.....	—

MISCELLANEOUS.

Telegraph Construction	35½,	36½	.....	37½	.....	36¾
India Rubber, Gutta Percha, and Telegraph Works	23,	24	.....	24½	.....	23¾

TRAFFIC RECEIPTS FOR AUGUST, 1885.

Companies.	Aug., 1885.		Aug., 1884.		Increase.		Decrease.	
Brazilian Submarine	11,896	....	—	....	—	....	—	
Cuba Submarine	2,200	....	2,515	....	—	....	315	
Direct Spanish Telegraph	1,276	....	1,190	....	86	....	—	
Eastern Extension	41,987	....	39,463	....	2,524	....	—	
Great Northern	24,000	....	—	....	—	....	—	
Western and Brazilian	7,153	....	—	....	—	....	—	

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NOTES.

DIVIDEND.—A return of 5s. per share is announced by the liquidator of the Devon and Cornwall Electric Light and Power Company.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ending 31st August amounted to £3,780.

THE LALANDE-CHAPERON BATTERY.—The Lalande-Chaperon (oxide of copper) battery has been adopted for exchange and line service by the Société Générale des Téléphones of Paris.

TELEGRAMS FROM SPAIN.—A telegram from Spain, dated Sunday night, says:—There are still great delays in the transmission of telegrams from Madrid, and telegrams in cipher have been entirely stopped.

NOTES FROM THE FAR EAST.—The telegraph line opened to Bokhara is said to be much appreciated by the traders. The men sent to Bombay to learn the working of the electric light have returned to Cabul.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th September are £2,027, as compared with £2,134 in the corresponding period of 1884.

ANTWERP EXHIBITION AWARDS.—The "Phœnix" dynamo has been awarded a gold medal at the Antwerp Exhibition.—The Patent "Berthoud-Borel" Electric Cables of the Kinetic Engineering Company have also obtained a gold medal.

THE TELEPHONE IN BELGIUM.—The subscribers to the different telephone exchanges in Belgium continue to increase in number. At the end of July, 1885, there were 774 subscribers in Brussels; 971 in Antwerp; 198 in Charleroi; 374 in Ghent, and 356 in Verviers.

INTERRUPTIONS.—It is announced that the cables between Dominica and Martinique, and between St. Vincent and Grenada are interrupted, thus cutting communication with Martinique, St. Lucia, St. Vincent, and Barbadoes. Messages can be sent by special boat with a delay of about five hours.—The cable between Fao and Bushire is also interrupted.

THE SS. "SHERARD OSBORNE."—The Eastern Extension, Australasia, and China Telegraph Company's steamer the "Sherard Osborne," Captain Worsley, left the New Harbour Docks (Straits Settlements), on August 5th, for Sydney and Melbourne, to lay a cable between the last-named place and Tasmania, and then to proceed to New Zealand to repair the cable in Cooks' Straits.

A CURIOUS ACCIDENT.—The *Scientific American* contains an account of a curious accident which recently happened at Camilla, N.Y. It appears that five horses were standing with their necks over a wire fence, when suddenly a flash of lightning struck the fence at a distance of 1,000 feet from the animals. The current traversed the wire, and went to earth through the horses, killing them instantly.

APPOINTMENT.—Mr. Reginald Webb, who has for the last five years occupied a post in the office of the accountant to the Anglo-American Telegraph Company, has just been appointed traffic manager to the West Coast of Africa Telegraph Company, and will proceed soon to Bathurst, near the Gambia. The cables will be made and laid by the India Rubber, Gutta Percha, and Telegraph Works Company.

AN ELECTRIC RAILWAY FOR BOSTON, U.S.A.—It is reported that Boston will soon have an opportunity to see the practical workings of the electric railway system on one of her streets. A line is being laid on Huntington-avenue in connection with the Metropolitan Street Car line. If it works satisfactorily there, after a thorough test, it will probably be adopted on some one or more of the roads in Boston.

THE ELECTRIC TRAMWAY AT BLACKPOOL.—As a result of Major-General Hutchinson's recent inspection of the electric tramway line on the Promenade at Blackpool, the town clerk has received the certificate of the Board of Trade that the permanent way is fit for public traffic. It is expected that the line will be worked by horses until the *fête* on September 29th, when it will be formally opened by the Mayor of Manchester, and the cars run by electricity.

UNDERGROUND WIRES IN BROOKLYN.—It is stated that the Brooklyn Commission on putting electric light wires underground will begin an experiment with the wires of the New York and New Jersey Telephone Company, on Fulton and Washington Streets. It is said that there are in that city 5,508 telegraph poles, 3,855⅝ miles of overhead wires, and 6·21 miles of cables. Additions by the Fire Department to the overhead wires will make the length 3,900 miles.

THE ELECTRIC LIGHT IN AN ABBEY.—The electric light has been installed in La Trappe de Bonneval (Aveyron). The dynamo, a small one, giving 15 amperes with a difference of potential at the terminals of 45 volts, is driven from a turbine, and charges a battery of 20 accumulators. The lamps employed are, of course, incandescents, of 2, 5, and 10 candle-power. Of the first there are 18 (8 volts, 0·9 ampere), 8 of the second (12 volts, 1 ampere), and 12 of the latter (34 volts, 0·8 ampere).

MALTON PUBLIC LIGHTING.—The Malton Local Board have lately taken the unusual step of advertising for tenders for the lighting of the public lamps of the borough. The clerk said that only one tender—that of the Malton Gas Company—had been received. Mr. Webster, the borough surveyor, reported that he had an offer to light the town by electricity, but the clerk reported that he was only instructed to advertise for gas tenders. Malton has something to learn yet, evidently.

POST OFFICE TELEGRAPHS.—At a recent meeting of the Wirrall Highway Board an application was read from the superintending engineer of the Postal Department, requesting the Board's permission to open up the ground on the Chester and Birkenhead-road between Backford Canal Bridge and Union-street, Tranmere, for the purpose of laying down a line of 3in. cast-iron socket pipes and telegraphs from Chester to Birkenhead. The request was granted, subject to the usual conditions.

THE TELEPHONE IN VENEZUELA.—The returns from Venezuela received by the Inter-Continental Telephone Company show that the result of the business for the quarter ending June 30th, 1885, was:—From rentals of subscribers at Caracas, La Guayra, Valencia and Porto Cabello, 7,880·91 dols.; from trunk lines between the cities, 3,172·50 dols.; total gross, 11,053·41 dols.; expenses same period, 4,616·77 dols.; net profits, 6,436·64 dols.; as against net profits for the first quarter of this year, 5,232·59 dols.; gain, 1,204·05 dols.

AN IMPUDENT THEFT.—It was recently discovered at Conshohocken, Pa., that three unknown thieves had mounted the telegraph poles from West Conshohocken to Bala station, a distance of seven and a half miles, and had stripped and stolen two lines of copper telegraph wire of the Postal Telegraph Company. The total length of wire stolen is 15 miles, weight nearly a ton, and value £100. The thieves operated in broad

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daylight, passing along the road in a waggon, removing the wire and acting as if they were authorised *employés*.

CONTINENTAL ITEMS.—The installation in the Theatre Royal, Berlin, has given great satisfaction. The precincts of the Cathedral at Milan are now lighted by 15 arc lights of 1,000 c.-p. each. The New Theatre, which will be opened at Naples on the 1st proximo, has been provided with an installation of the electric light to the exclusion of all other illuminants. An installation is about to be put down in the workshops in connection with the construction of the large bridge over the Pô for the Parma-Casal-Maggiore-Piaderna Railway.

TOOK IT FOR A FIRE!—Our American namesake says:—At the southern limit of Chicago, on Cottage Grove-avenue, a new arc plant was recently installed, and the light suddenly flashed upon the vision of a fireman in the adjoining town of Lake. As the source of the light was hidden from view, and as he was unaware of the existence of the plant, duty compelled him to turn in a fire alarm. This is about as near as Chicago has ever come to having a fire from electric lighting, and should be noticed by the gas people as "almost a dangerous fire from electricity."

A CURIOUS EFFECT OF ELECTRICITY!—At the Croydon Borough Police-court recently, an elderly man, describing himself as an engineer, without a home, was charged with being a lunatic at large, and not under proper control. An officer said he found the defendant conducting himself in a peculiar way in North-end on the previous night. The defendant: "May I speak a word?" The Mayor: "Yes; certainly." The defendant: "I will tell you what has upset me. It is this American coming over here and charging the earth so heavily with electricity that has caused me to go giddy in my head." The Mayor sent him to the infirmary.

THE ELECTRIC LIGHT IN GUAYAQUIL, EUCADOR.—The Thomson-Houston International Electric Company has, we are informed, made a contract for furnishing a large electric light plant, combining arc and incandescent lights, for the city of Guayaquil, Ecuador, where a local company has been formed. The city has agreed to adopt the system permanently for street lighting purposes, and the present plant will be increased as rapidly as possible. The entire city will require about 150 arc lamps, besides a large installation of incandescents, which have already been ordered.

THE SELF-INDUCTION OF A COIL.—In order to determine the self-induction of a coil, the following method may with advantage be employed. Divide the current from a constant battery between a galvanometer circuit, in which is a coil, and a shunt circuit. At a given moment of time interrupt the shunt circuit and then the galvanometer circuit. Now, if P be the self-induction of the coil, it can readily be calculated from the throw of the galvanometer needle, the exact interval of time between the two interruptions having, of course, been correctly ascertained.

THE EARTHQUAKES.—The *Official Messenger* states that the city of Namangan, in Ferghana, where Skobeleff distinguished himself in the campaign against Khokand, has been visited all through the summer by repeated shocks of earthquake, which have hitherto been of very rare occurrence in those parts. The strongest shocks took place on April 17th and August 4th, but no very serious consequences resulted.—Repeated shocks of earthquake have occurred in the south-east of Lower Austria and in the north of Styria, and have been followed by shocks in Bosnia, described as moving from east to west.

APPOINTMENT.—We are informed that the vacant Chair of Physics and Engineering in University College, Bristol, has been filled by the appointment to the post of Prof. John Ryan, M.A., King's College, Cambridge, D.Sc., London, and member of the Institute of Mechanical Engineers. Dr. Ryan, who is a practical engineer, has hitherto held the appointment of Professor of Mechanics and Engineering in University College, Nottingham. At Bristol he succeeds Prof. Thompson, now Principal of the Finsbury Technical College, and Prof. Hele Shaw, recently appointed to the Professorship of Engineering in University College, Liverpool.

TELEPHONE CABLES.—We understand that Messrs. W. F. Dennis and Co. are continuing to receive large orders for Felten and Guilleaume's anti-induction telephone cables. Among the more recent demands, we may mention those of the Lancashire and Cheshire Telephonic Exchange Company for one and a-half mile lead covered cable, No. 19, copper; the Swiss Confederation Telegraph Department, seven miles of 27 core cable; Royal Bavarian Postal and Telegraph Department, four and a-half miles for the Nuremburg telephonic system; Copenhagen Telephone Company, 13 miles, 27 core; Imperial German General Post Office, nine miles, 27 core; &c., &c.

MEASUREMENT OF DISTANT TEMPERATURES.—At the Academy of Sciences, St. Petersburg, recently, Dr. Lent described a new and accurate method of measuring distant temperatures. This, it would appear, is based upon the known fact that a thermo-electric current is produced in an arrangement of two wires of dissimilar metals, such as iron and silver, soldered at their two extremities, when one of the junctions is at a different temperature to the other. A galvanometer is put into circuit, and the union at one station is gradually heated until the deflection shown by the galvanometer disappears. When this is the case the two temperatures would presumably be equal.

ARC LIGHTS AT THE ANTWERP EXHIBITION.—The arc lamps lighting the Antwerp Exhibition are distributed as follows:—Compagnie Générale d'Electricité of Brussels, 25 Gülcher (six with reflectors), 9 Gramme, and 8 Jablochkoff arcs; Société l'Electrique de Brussels, 45 Brush arcs; Ganz and Co., of Buda-Pesth, 20 Zipernowsky arcs; Heilman du Commun, of Mulhouse, 13 Gramme and Cance arcs; M. Jaspar, of Liège, 32 De Puydt and 6 Jaspar arcs; M. Pieper, of Liège, 24 Pieper arcs; Scrive, Hermite and Co., of Lille, 52 Patterson arcs; Spiecker and Co., of Cologne, 32 Spiecker arcs; Société des Forges de Gilly, 4 Crompton arcs; Schuckert and Co., 22 Piette and Krizick arcs. Besides these there are, of course, a large number of incandescents.

DEPREZ'S PROPORTIONAL GALVANOMETER.—According to the *Centralblatt für Elektrotechnik* this galvanometer consists of five permanent steel magnets of horseshoe shape placed horizontally one above the other, a pole piece being fitted on each leg of this compound magnet. The two pole pieces are hollowed out to a true cylinder, inside which is suspended an iron tube having a coil of wire wound on it, lengthwise. The iron cylinder, being close to the pole pieces, the magnetic field is both powerful and uniform. The iron cylinder and its coil of wire are supported by two stretched wires, one above and the other below, which serve at the same time to make connection to the coil. A pointer and scale complete the instrument, which gives reliable readings up to 120°.

CABLES FOR THE INDIAN GOVERNMENT.—The India Rubber, Gutta Percha, and Telegraph Works Company are at present shipping into their steamers "Dacia" and "Inter-

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national" 513 miles of cable for the Indian Government, to be used for renewal of part of the first Persian Gulf Cable, laid in 1864. The whole work is being carried out under the superintendence of Lieut.-Colonel S. V. Bateman-Champain, R.E., the Director-in-Chief of H.M. Indo-European Telegraph Department, assisted by Sir H. Mance, C.I.E., the inventor of the heliograph. The testing of the cable during manufacture has been entrusted to the well-known firm of Clark, Forde, and Taylor, and Mr. F. C. Webb has also been consulted as to the machinery, distribution, of the cable and list of stores.

LAUNCH OF THE "RECORDER."—Recently Messrs. Robert Napier and Sons launched from their shipbuilding yard at Govan a steel telegraph cable steamer for the Eastern Extension, Australasia, and China Telegraph Company. The vessel, which was named the "Recorder," is something similar in construction to the "Magneta," lost last winter. She is 320 by 32 feet, and 24 feet deep, with a tonnage of 1,150. Her engines are of the compound type, capable of driving the ship at a speed of about 12½ knots an hour. Being intended for laying and repairing submarine cables, the vessel has been fitted with all the necessary gear and appliances, and has been subdivided into no less than 27 watertight compartments. The "Recorder" has been classed 100A at Lloyd's under special survey.

VON BEETZ'S GALVANOMETER.—This galvanometer, which has been designed for the purpose of experimental demonstration to large audiences, is constructed as follows:—In the centre of a circular metal plate, fitted with levelling screws, is a copper damper for the bell magnet, which is suspended from a fibre. On the damper are mounted two small columns, which carry the suspension tube. On one side of the suspended needle is a coil of thick wire, on the other side a coil of thin wire, the connections to which are carried through the base plate. Concentric with the axis of the needle is a large upright metal ring on which the divisions are marked in large figures. To the suspension of the needle is fixed a straw, carrying at its end a piece of white paper, which moves over the upright scale.

CAMBRIDGE LOCAL EXAMINATIONS.—The forms of entry for the Cambridge Local Examinations, to be held Dec. 14-19, can now be obtained from the local secretaries. All forms must be returned, duly filled, before Oct. 1. There will be a Higher Local Examination on the same days (in Groups B and C only), at the Cambridge centre, and also at the London centre, if a sufficient number of candidates apply to the local secretary before the 30th inst. The Syndicate have made the following alterations in their regulations for December:—Alternative papers will be set on Friday afternoon, Dec. 18, from 3 to 5 p.m., in the following subjects, for the convenience of candidates who wish to take papers set at the same time with these on Saturday morning:—Juniors: Mechanics (Sec. 7). Seniors: Statics, Dynamics, and Astronomy (E. 3); Statics, Dynamics, and Hydrostatics (F. c); Electricity and Magnetism (F. e).

THE TELEPHONE IN WEST CUMBERLAND.—Telephonic communication has recently been opened from the Whitehaven Exchange to the Parkside Mining Company's mines at Frizington, and to the mine of the Maryport Hematite Iron Company at Pallaflat. The opening of these routes completes the skeleton of the National Telephone Company's West Cumberland system, with the exception of the projected spur from Workington to Cockermouth, for which sufficient support has not been obtained. It is now possible to telephone from Whitehaven to Frizington and Pallaflat on the one hand, and to Workington and Maryport on the other, as well as between any two of those places. The longest distance that can be telephoned over at present in West Cumberland is about twenty-one miles, namely from Maryport to Pallaflat. In other districts the National Company have wires of over fifty miles in length.

SOME AMERICAN NOTES.—A proposition was recently made by a representative of the Evanston, Ill., Electric Light Company, to the trustees of that village, to light the streets by means of electricity. For the sum of 3,000 dols. the company proposes to place 30 arc lights at points where the trustees may direct, and maintain the same. In return they want an ordinance giving them the exclusive right to operate and maintain the business of electric lighting, together with the necessary license for erecting poles, &c.—A contract was signed 28th August, in New York City, by the American Electric Manufacturing Company and E. A. Noyes, chairman of the Street-Lighting Committee of Portland, Me., providing for the lighting of the streets of that city by electricity, at a cost of 25,000 dols. per year.—Fargo is preparing to erect three electric light towers.—Meadville, Pa., is contemplating having an electric light plant.

UNDERGROUND WIRES IN NEW YORK.—The Commission on Electrical Subways has held several meetings for the reception of plans for burying the wires. The following resolution was adopted on 13th August:—"Resolved, That every corporation, association, or person using or desiring to use any electrical conductor in the City of New York, do forthwith file with this Board such map or maps and other suitable descriptions as will fully inform this Board concerning the location, courses, termini, space, and all other details and requirements concerning the electrical conductors operated or desired to be operated by such corporation, association, or person in the City of New York, to the end that this Board may be enabled to make due provision for said conductors in the general plan and subway to be devised as aforesaid, and which it has full authority to require to be used for all the electrical conductors aforesaid."

LIGHTNING-STRUCK TREES.—A correspondent of *The Times* writes as follows:—"The most probable cause of the liability of certain trees to be struck by lightning is that they are bad conductors of electricity. The suggestion that oak trees are struck because they contain iron is both erroneous and absurd. If oak did contain iron it would in all probability increase its conducting power and act as a preservative. If oak contained an estimable quantity of that metal the wood would turn black on exposure to air, on account of the tannin which is present. This blackening may be seen surrounding the iron nails in any oak fence. The contour of the ground, nature of the soil, and the presence or absence of water have more influence in deciding the locality of an electric discharge than the height of a tree. Add to this the difference in conductivity between various woods and we have at once an explanation of the apparent peculiarity of tall trees escaping unharmed while shorter trees are destroyed."

RECENT INSTALLATIONS.—Messrs. B. Verity and Sons, of Covent Garden, have obtained the contract for the whole of the electric lighting at the new Constitutional Club next to the Grand Hotel, Northumberland Avenue. A view of this new building appeared in the *Graphic* a fortnight ago. There are to to be over 700 lamps in all, the light being also used in the kitchens, &c., and the machinery being in complete duplicate; the total capacity of the entire plant is to be 1,500 lamps. High-speed engines and the newest type of Edison dynamo machines, made in New York, will be used. Special double pole safety-blocks in earthenware will be used for this

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installation. No expense will be spared to make this a model installation. We believe Sir Wm. Thomson is to be the advising electrician. The same firm are also installing nearly 600 16 candle-power incandescent lamps in the Criterion Restaurant. Owing to the extensive character of the building the wiring is of a difficult character. The grill room and buffet are already lighted up, the fixtures being glass pendants of quite a new design.

THE INSTITUTION OF CIVIL ENGINEERS.—From an abstract recently issued by the Institution, we notice amongst the subjects upon which original communications are invited by the Council the following:—"Electric-motors; their theory, practical construction, efficiency, and power." "The Construction of Dynamo-electric Machines and their Prime-movers." "The Working and Cost of the Treble and Double-wire Systems of Distributing Currents for Electric Lighting," and "Thermo electric Batteries, and their Application to Electric Lighting, Electro-plating, and other purposes." Among the premiums awarded for papers during the Session, 1884-85, are the following:—A Telford medal and a Telford premium to Peter William Willans, for his paper on "Electrical Governors;" a Telford premium to Andrew Jamieson, F.R.S.E., Assoc. M.Inst.C.E., for his paper "Electric Lighting for Steamships;" a Telford premium to Claude William Kinder, Assoc. M.Inst.C.E., for his paper "Notes on Electric Blasting in China;" and a Miller prize to Frank Geere Howard, Stud. Inst. C.E., for his paper on "Secondary Batteries."

A LABORATORY EXPERIMENT.—An investigation has been made by Herr W. Peukert, at the laboratory of the Technical High School of Hanover, for the purpose of determining how much of the electrical energy supplied to different types of incandescent lamps reappears as light and heat respectively. In these experiments the heat evolved from the lamps was ascertained by registering the rise in temperature of a weight of water in which they were immersed for a stated time. The photometrical measurements were made by the aid of Von Hefner-Alteneck's normal flame. The illuminating power of the various lamps experimented upon was recorded while they were immersed in water as well as when hanging in air, the loss of light in the former case being from one twenty-fifth to one-eighth with different lamps. As the result of Herr Peukert's examination, it appears that in one of Siemens and Halske's 8-candle incandescent lamps, 74 per cent. of the total work of the current was lost as heat, while 26 per cent. was represented by the light emitted. With Edison's 16-candle lamp, 66 per cent. of the current was returned as heat, and 34 per cent. as light. In Swan's 30-candle lamp, 72 per cent. of the current was transformed into heat, and 28 per cent. into light.

MURDER.—The American papers contain an account of a murder which occurred in the city of Lawrence, Mass., on August 27, both parties being well known citizens who had been intimately associated with each other in the telephone business. Henry K. Goodwin, at ten o'clock on the morning of that day, called upon Albert D. Swan at his office, where they engaged in conversation regarding previous business transactions. The bookkeeper in the adjoining room was soon after startled by the sound of a pistol shot, and turning quickly saw Mr. Swan reel and clutch the corner of his desk, with blood spurting from a wound in the back of his head. He fell to the floor and died in a few moments. Goodwin, who had deliberately shot him with a 32-calibre revolver, walked over to the telephone, notified the police that he had committed the deed, and offered to deliver himself up. He alleged that Swan had robbed him of all he possessed. The murderer was one of the pioneers in the telephone business, which he embarked in as a member of the firm of Goodwin and Caldwell. Selling out to Swan and his partner, he went to Buenos Ayres in charge of the Bell telephone system there. Returning two years ago he entered the employ of the Molecular Company. He is a native of Lawrence, where he has a family, and is about thirty-eight years of age.

CONCOCTED TELEGRAMS.—"It must be obvious to every one that the great telegraph companies have it in their power (and it would certainly be to the interest of their shareholders) to expose and put an end to the shameless manufacture of pretended foreign telegrams. When they find that a message has been entirely fabricated, or that it has been imprudently 'expanded,' they owe it as a duty to the public to at once declare what was really the number of words, if any, which passed through their wires. Slight discrepancies explainable by the addition of articles and other unimportant words for the sake of greater clearness no one would consider a reproach. Deliberate manufacture, however, should be mercilessly exposed, and thus the public would not only be able to give credit to enterprise where credit is really due, but would have a means, at present denied to them, of judging of the authenticity of the news submitted to them." The foregoing appeared in the correspondence columns of a recent issue of the *The Times*. Its author has apparently not taken into consideration two facts, *i.e.*, that the telegraph companies are paid to transmit messages and not to gossip (secrecy is, of course, the most essential point); and that if they were disposed to commit what would be nothing less than a breach of confidence, it would be impossible for them to speak with any degree of certainty, for the reason that a very large number of the messages transmitted by them are in code, and the mere mention, therefore, of the precise number of words contained in any particular telegram passing over these lines would afford no indication to the actual number in its text.

THE NEW TARIFF FOR TELEGRAMS.—A correspondent of the *Daily Chronicle* takes exception to the charge of 2d. made by the postal authorities for telegram receipts. He says:—"It is stated upon the new form of telegram that 'a receipt for the charges on this telegram can be obtained, price 2d.' It is not easy to understand the existence of any considerable demand for such a receipt or why so much should be charged for the rendering of so small a service, and in contrast with the considerable reduction made by the new rate it seems very disproportionate. The idea of charging 2d. for giving a receipt for 6d. is a shock to common sense, and is absurd. I venture to suggest that a 1d. at the most should be charged for this receipt, and that for 2d. the telegraph officials should examine and stamp with the stamp of the office, as certifying the same to be correct, a copy of the telegram to be made by the sender. Under the last Bankruptcy Act the contracting stationers of the Court made, examined, and obtained the seal of the Court to copies of documents filed at a remuneration of 2d. per folio of 72 words, and I have reason to believe the contract was not unprofitable to them. The Post Office might well, then, for this sum peruse and stamp a paper containing on the average not a quarter of such a length. If the suggestion I make be adopted it will, I believe, be a great gain to those engaged in professional life, as well as to those engaged in the circles of commerce."

THE ELECTRIC LIGHT AND COLLIERIES.—An installation of incandescent lamps, supplied by the Maxim Weston Electric Company, and fitted up under the supervision of Mr. W. C. Cockburn, their agent in Newcastle, was recently tested at Ashington Colliery. The Ashington Company naturally

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desire to have their heapstead illuminated as perfectly as possible, and no expense has been spared to achieve that end. There are three dynamos, two of which are capable of supplying 60 circuits of 20 candle-power, and thirty of 50 candle-power. At present, however, only about fifty 20-candle and twelve 50-candle lamps have been fitted. The third dynamo is to work two arc lamps of 2,000 candle-power. The incandescent lamps are distributed at the pit heap and screens, and when in use gave a steady glow that is much admired. It is evident that but trifling alteration of position is requisite to make their application a perfect success. The two arc lamps, suspended at the extreme ends of the heapstead, and intended to illuminate the sidings, &c., give the utmost satisfaction. On the occasion of the trial run they burned clearly and steadily during the whole of the night, and gave a beautiful illumination of the area in front of the pit. The company seem to have made colliery illumination a special feature, for they have already fitted up Cornsay, Burradon, and Page Bank Collieries, and made an installation at Backworth a few nights ago.

A Plea for De Sauty.—In a letter to the American *Operator*, and under the above title, Mr. T. D. Lockwood gives a brief biographical sketch of Mr. C. V. de Sauty, who will be known to many of our readers. The following is the substance of Mr. Lockwood's letter:—"Mr. C. V. de Sauty was simply the operator—nothing more—at the Newfoundland end of the short-lived Atlantic cable of 1858. The cable of 1858 was successfully landed on 6th August, and was operated by the 10th; it worked with some degree of success until the 1st of September, exactly 23 days. The messages show Mr. de Sauty to have been what he truly was, an industrious, ingenious, able and careful electrician. He had no particular desire to be immortalised as an optimist in cable matters, but he naturally telegraphed from Newfoundland to New York to his superiors the state of the cable from day to day, and they equally naturally published his statements. The cable lived long enough to save the British Government 250,000 dols., by enabling them to regulate the movement of troops, and finally gave out on the very day that the New York celebration in its honour was held, after four hundred messages, comprising 21,421 letters had been transmitted over it and understood, ten messages having been transmitted on the very last day of its life, September 1, 1858. De Sauty, instead of being desirous of issuing daily bulletins of 'all right,' was noted for his extreme reticence, and only occasionally could be induced to say anything about the cable; and once visited by some United States coast survey officers, refused to allow them to enter the office or examine the apparatus. He was subsequently engaged on the later expedition of 1865, acting as electrician on the 'Great Eastern,' and in 1866 was appointed electrician of the Malta and Sicily Cable Company. Still later he filled for some years with great ability the office of electrician of the Gibraltar and African Cable, being stationed at Gibraltar, and while there made seem valuable inventions in duplexing submarine cables. I have for some time lost sight of him, but I am of the impression that he died about two years ago." We are happy to be able to give our readers and Mr. Lockwood some further information in regard to this gentleman, and to correct one or two of the statements contained in the letter we have quoted. Subsequent to the decease of the 1858 cable Mr. de Sauty was engaged as electrician-in-chief of the firm of Messrs. Glass, Elliot, and Co., afterwards the Telegraph Construction and Maintenance Company, and on the later Atlantic Expedition of 1865 acted as electrician on the "Great Eastern." After the 1866 Atlantic Expedition he visited New Zealand, where he remained in the telegraphic service until 1870, when he joined the Falmouth, Gibraltar, and Malta Telegraph Company, and was appointed superintendent at Gibraltar. He is still alive, and retains direction of the Gibraltar station in the service of the Eastern Telegraph Company.

The Bessbrook and Newry Electric Tramway.—On Saturday last a special trip was made over the new electric tramway line from Newry to Bessbrook, the construction of which has just been completed, and the official inspection of which has just taken place. Amongst those present at the trial trip were Mr. J. L. D. Mears, C.E. (chief engineer of the line), Dr. John Hopkinson, F.R.S., London; Dr. Edward Hopkinson, electrical engineer; and others. The new line, although but little more than half the length of the Portrush and Bushmills line, yet presents many new and improved features. One great difficulty in connection with all railways and tramways heretofore has been that the rolling stock cannot be used on the ordinary public roads. This difficulty, we are informed, the promoters of the Newry and Bessbrook Tramway Company have solved in a most satisfactory manner. The generating dynamos, two in number, have been fixed at Millvale, where a turbine has been erected. They are of the Edison-Hopkinson type, manufactured by Messrs. Mather and Platt, of Manchester. The present machines were designed by Dr. Edwd. Hopkinson especially for the purposes of this line. The current from the generating dynamos is conveyed from a convenient switch-board to a central rail, and from this rail the current is conducted to the receiving dynamos on the car. The cars are geared so as to run at a maximum speed of fifteen miles per hour, and this speed is easily attained. They are carried on bogies at either end, and though 35 feet long pass easily over any of the turns or curves on the line. At each terminus there is a pear-shaped loop, around which the cars pass for reversal and return. The line has been constructed, not on the public road, but across the country. Only at one point does it touch the public road, namely, at Millvale, where there is a level crossing over fifty yards in extent. The electric conductor at this point is stretched overhead, at a height of 15 feet, supported at either end by poles. This plan has been patented by Dr. John Hopkinson, F.R.S., and would of course be applicable for the whole line if so desired. The plan, by which the difficulty has been overcome and by which the waggons used on this line can be also used on the ordinary public roads, &c., is the invention of Mr. Henry Barcroft, of Newry. The wheels of the waggon are constructed without flanges, and of a sufficient width of tyre to run upon ordinary roads. By the side of the ordinary tramway rails second rails have been laid at a lower level, on which the flangeless wheels run, while the electrical locomotive car is fitted with ordinary flanged wheels, and runs upon the inside rail, which acts as a flange to the waggon wheels. The front part of the waggon is carried on a bogie, which can either be pinned so as make a fixed wheel base, or can be allowed freedom of motion as in an ordinary loaded vehicle. To the fore bogie horse shafts can be attached when the waggon is to be used on the ordinary roads. These waggons are constructed to carry two tons. The maximum gross load carried is 26 tons, the electrical locomotive weighing eight tons, and being capable of carrying 34 passengers. This load can be brought up inclines, averaging one in 85, at a speed of seven miles per hour, and can be started at any point of the line, even where the gradient is as steep as one in 50. This is very much in excess of the work done at Portrush. All the electrical details and all the matters connected with the electrical equipment of the line have been designed and carried out by Dr. Edward Hopkinson, of Manchester.

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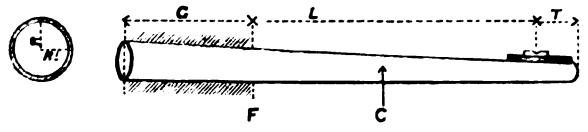
ON THE STRENGTH OF ROUND TIMBER.

By W. H. Preece, F.R.S., M.Inst.C.E. A Paper read before the British Association at their meeting at Aberdeen.

TABLE I.—*Tests of Ten Creosoted Poles* (A to K), *and of a Red Deal Scantling* (l), *made at* Gloucester-road Factory (January, 1885).



Details of **L** *and* **T**.

M = cubic contents : feet.

C = distance of centre of gravity from F.

W = weight in lbs.

Details of Load.

$W^1 = \frac{W \times C}{L}$.

$W^2 = \left\{\begin{matrix}\text{Jockey ... 9}\\ \text{Saddle tree 84}\\ \text{Scale..... 165}\\ \text{Chain ... 35}\end{matrix}\right\} = 293.$

$W^3 =$ Added load.

For poles $= \frac{W \cdot L}{47 \cdot (R^2 \times R^1)}$.

For scantling $= \frac{W\,L}{D^2\,B}$.

Index.	Pole. Length.	Class.	Weight per cubic ft. in lb.	G	L	T	Section at F. R	Section at F. R^1	M	C	W	Weight in lbs. W^1	W^2	W^3	W	Value of K in formula $W = K\frac{4\cdot7\,R^3}{l}$ Results in lbs.	Mean value of K in formula, $W = K\frac{d^3}{l}$ for stout poles in lb.	Relative area of Section F.	Relative value of K	When Creosoted.	
	ft. in.			in.	in.	in.			c. ft.	in.	lb.										
a	26 3	Stout	41·9	60	214	41	4·1	3·9	6·02	110	252	129	293	1431	1853	1286·88		5	3	Early in '81	(1)
b	26 2	,,	37·3	60·5	212	41·5	4·2	4·15	6·31	109	235·4	121	293	1723	2137	1316·672		6	5	Ditto	(2)
c	28 4	,,	49·0	67	239	41	4·6	4·55	7·99	116	391·5	190	293	2019	2502	1321·488		9	7	Ditto '82	(3)
d	30 0½	,,	51·0	60	252	41	4·45	4·4	7·97	122·5	406·5	197	293	1656	2146	1320·48		8	6	Dec., '84	(4)
e	34 5	,,	44·1	66	306	41	5·0	4·75	11·13	136·5	490·8	219	293	1797	2309	1265·936		10	2	May, '82	(5)
f	24 1	Light	50·7	54·5	193	41·5	3·55	3·45	4·09	96	207·3	103	293	1175	1571	1483·776		1	10	Sept., '84	(6)
g	26 0	,,	49·7	60	209	41	3·7	3·6	4·8	108	238·5	123	293	1212	1628	1468·880		2	9	Ditto '83	(7)
h	28 1	,,	47·3	60·5	235	41·5	3·95	3·75	5·46	110·5	258·2	121	293	1107	1521	1299·766		3	4	April, '82	(8)
i	29 10½	Stout	45·2	64·5	252	41·5	4·05	3·95	7·69	142	347 5	196	293	949	1438	1190		4	1	Ditto '84	(9)
k	33 8	,,	39·5	66	298	40	4·5	4·2	8·78	143	346·8	166	293	1442	1901	1417·136		7	8	'70 or '73	(10)
							D	B									765·2512				
l	13 11½	...	32·3	36	89	42·5	5·5	4·0	1·67	65·75	54·2	40	120	789	949	698·0176		...	...	...	(11)

Constant mean of *a*, *b*, *c*, *d*, *e*, *i*, *k*, for formula, $W = K\,4\cdot7\,\frac{R^3}{l} = 1302{\cdot}56$ lb.

Ditto ditto for formula, $W = K\frac{D^3}{l} = 765{\cdot}2512$ lb.

Quality of Timber and Remarks.—(1) Very hard grown ; (2) medium grown ; (3) medium grown, sapwood large, fracture flakey ; (4) very hard grown ; (5) medium hard grown ; (6) medium hard grown ; (7) medium hard grown ; (8) very hard grown ; (9) very hard grown ; (10) very hard grown, fracture flakey ; (11) rather a coarse piece, placed in error heart side up, fracture at a knot just inside F. (Note.—Some of the poles fractured by elongation of the upper fibres, some by compression or buckling of the lower ones.)

TABLE II.—*Further Pole Tests made at* Gloucester-road Factory (in April and May, 1885), *viz., six indexed l, m, n, o, p, and q, creosoted and erected in* 1870 *or* 1871, *and three uncreosoted indexed r, s, and t, imported in* 1884.

Index.	Pole. Length.	Class.	Weight per cubic foot.	G	L	T	Section at F R	Section at F R_1	M	C	W	Weight in lbs. W^1	W^2	W^3	W	K for result in lbs.	Relative area of section at F	Relative value of K	When creosoted.	Load lbs., when $W^2 + W^3$ was equal.	Deflection.	Recovery when weight removed.	
	ft. in.		lb.	in.	in.	in.	in.	in.	c. ft.	in.	lb.										in.		
l	28 0	medium.	40·22	64	231	41	4	3·6	5·81	120	234	121	293	1342	1756	1497·44	1	8	1870 or 1871.	1414	32	recovered	(12)
m	26 0	stout	42·46	66	204·5	41·5	4·75	4·25	6.56	98	279	133	293	1674	2100	952·8736	8	1	,,	1776	27	,,	(13)
n	26 0	,,	36·85	65	205·5	41·5	4·4	4·1	5·55	95	204	95	293	1530	1918	1056·5072	6	3	,,	1250	23½	,,	(14)
o	27 11	medium.	40·45	64·5	229	41·5	4	4	6·53	121	264	139	293	1518	1950	1484·448	3	7	,,	1355	29	,,	(15)
p	26 0	stout	40·93	64·5	206	41·5	4·3	4	5·72	103·5	234	117	293	1339	1749	1036·4816	4	2	,,	1480	27	,,	(16)
q	26 0	,,	43·11	65·5	205	41·5	4	3·7	5·49	109·5	237	126	293	1789	2208	1626·8	2	9	,,	1700	28	recovered	(17)
																				1969	35	"all but 1½in.	
r	29 7	,,	35·27	66·5	247	41·5	4·8	4·6	8·08	113	285	130	293	1794	2217	1099·3136	9	4	uncreo	1629	35½	recovered	(18)
																			soted	1855	43½	"all but 2in.	
s	30 0	,,	34·06	66	252·5	41·5	4·5	4·25	7·72	122	263	127	293	1602	2022	1262·128	7	5	,,	1668	36½	recovered	(19)
t	29 10½	,,	39·97	66	251	41·5	4·3	4·25	7·58	124	303	149	293	1520	1962	1333·360	5	6	,,	1280	31	recovered	(20)
																				1429	48	'all but 3½in.	(21)

Note.—For explanation of the headings see Table of Tests *a* to *k*, made at Gloucester-road Factory in January, 1885, Table I.

Note.—Poles indexed ..... *l* to *q* are believed to have been erected in 1871 or 1872.

,, ,, ... *m*, *n*, *p*, *q* were taken down in March, 1882.

,, ,, ... *l* and *o* were taken down in August, 1883.

Quality of Timber and Remarks.—(12) Hard grown, very sound, fracture 2ft. from **F** ; (13) sound timber, still smells strongly of creosote, fracture short 17in. from **F** ; (14) medium quality, fracture by compression 3in. from **F** ; (15) soft grown, fracture by compression 18in. from **F** ; (16) knotty and soft grown, fracture 3ft. from **F** ; (17) hard grown and tough, fracture by compression 18in. from **F** ; (18) soft, fracture by compression 18in. from **F** ; (19) sound hard wood, fracture 31½in. from **F** ; (20) no cut, fracture 2ft. from **F** ; (21) no cut, fracture 6ft. from **F**.

The resistance of timber to rupture has frequently been experimentally investigated both at home and abroad, but almost invariably with the view of determining the dimensions or scantling of beams, trusses, and framed structures. Few experiments have been made upon naturally grown trees with a view of utilizing them in their native condition.

Fincham's* experiments on the relative qualities of timber used for the masts of ships were made upon cut pieces, 4ft. in length and 3 square inches in sectional area. The strength of square balks was investigated by Messrs. Tredgold, Barlow, and others, the results giving a constant of 1,341 for red pine in the formula

$$w = K\frac{b\,d^2}{l} \quad \ldots\ldots\ldots\ldots\ldots\ldots 1$$

* "Papers on Naval Architecture," Vol. I., pp. 53-4.

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where w = breaking weight in lbs.
b = breadth in inches
d = depth ,,
l = length ,,
K = a constant dependent on the character of the timber.

The formula for round timber based on the same value of the constant K becomes

$$w = K \frac{4 \cdot 7 r^3}{l} \quad \ldots \ldots \ldots \ldots \quad 2$$

r being the radius.

The value of the constant quoted above was obtained by experiments on small sections of timber one and two inches square only. Wisely distrusting results obtained in this manner, Mr. Edwin Clark, during the construction of the Britannia tubular bridge, caused trials to be made with beams of red pine 12in. square, which gave a constant of 810 only, whilst experiments on balks of Baltic fir made by the Mersey Dock Board gave results varying between 771 and 873. Mr. Gavey, during certain investigations made in Bristol in 1876, obtained a constant of 804 from square sections cut out of Norway round telegraph poles.

Telegraph poles in England now consist principally of native grown unhewn Norwegian or Swedish red fir preserved with creosote.

They have acquired their pre-eminence by a species of natural selection, after extended trials of cut Memel timber, native grown larch, and preserved Scotch fir. The Scandinavian red fir is now almost exclusively employed. It seems to have been provided by nature specially for telegraphic purposes.

The specifications for telegraph poles, in addition to quoting dimensions, prescribe that they are to be winter felled, sound and hard grown (*i.e.*, well-hearted, with the annual rings closely pitched), straight, free from large or dead knots and other defects, to have the bark completely removed, and to contain the natural butt of the tree. They are usually from 5 to 6in. in diameter at the top, and they grow with a taper that accords satisfactorily with the theoretical law that should give the greatest strength at each section of their length.

No systematic inquiry has, so far as I am aware, been made into the mechanical properties of Scandinavian red fir in its native or unhewn state, though at different times isolated experiments have been made on its resistance to flexure.

The immense growth of the telegraph system in this country, the increased utilisation of public highways with their bends and curves, the wind pressures arising from the rapid multiplication of wires, have forced closer attention to the stresses applied, and to the more scientific bearing of the question. The selection of the proper scantling has been very much a rule of thumb process, but stability has been obtained by struts, stays, and double poles framed together. Subsequent experiments have, however, shown that practical experience has not erred in specifying dimensions.

As considerable doubt existed as to whether constants obtained from square timber could be accurately applied in calculating the strength of naturally grown trees, in which the annual rings of growth were unsevered, it was determined by the Post Office authorities to make careful and accurate measurements of the strength of the poles actually used, and a substantial testing apparatus was constructed for the purpose. A stout wrought-iron cylinder, 14in. in diameter and 6ft. long, was rigidly held down on a suitable framing by two 2in. tie rods. The butt of the pole to be tested was placed inside this cylinder to a depth of 5ft. 6in., carefully packed all round and tightly rammed with gravel to represent the conditions when in use. It was then placed horizontally, a scale pan was suspended from what would be the resultant point of a line of wires at the further end of the pole, and weights were added until the pole broke. An oak plank or saddle distributed the load as would be the case on an actual line of telegraph.

Table No. I. contains the results of the experiments made upon ten comparatively newly creosoted poles.

This gives a mean constant with formula 2 of 1,337, that obtained from the seven stout poles alone being 1,302, and from the thin light poles 1,417.

As the investigation referred primarily to lines built with stout poles, 1,302 is the value used in calculating subsequent tables.

Table No. II. contains the results of similar experiments made upon six old poles creosoted 15 years ago, and upon three new creosoted poles, the constants being 1,276 and 1,232 respectively.

As previously stated, formula 2 is really derived from experiments made on square timber, a multiplier being used to reduce results when round timber is in question. But obviously the strength of round timber varies as the cube of the diameter, so a constant has been obtained for the formula

$$w = K \frac{D^3}{l} \quad \ldots \ldots \ldots \quad 3$$

D being the diameter;

whilst for poles of elliptical section it becomes

$$w = K \frac{D^2 \times D_1}{l} \quad \ldots \ldots \ldots \quad 4$$

D being the axis in the line of stress, and D_1 that at right angles to it.

TABLE III.

The calculated strength of round poles, one foot long.

Diameter meters.	Breaking weight in lbs.	Diameter meters.	Breaking weight in lbs.
6	13,776	10	63,773
6·25	15,568	10·25	68,678
6·5	17,517	10·5	73,819
6·75	19,611	10·75	79,218
7	21,873	11	84,874
7·25	24,304	11·25	90,798
7·5	26,902	11·5	96,992
7·75	29,725	11·75	103,454
8	32,648	12	110,196
8·25	35,807	12·25	117,219
8·5	39,166	12·5	124,555
8·75	42,716	12·75	132,182
9	46,491	13	140,100
9·25	50,467	13·25	148,344
9·5	54,678	13·5	156,901
9·75	59,102	13·75	165,782

To obtain the strength of any pole divide the tabulated breaking weight by the length of the pole in feet between the ground line and the resultant point of the load.

The value of K, for formulæ 3 and 4, as deduced from the mean of the experiments on new stout creosoted poles, is 765.

It appears from these experiments that creosoting does not impair the strength of red fir, and age has had no apparent influence on its qualities.

The curves formed by the poles in bending were very perfect. Rupture invariably took place at the ground line, and about half broke by fracture of the upper fibres under tension, while the other half buckled in the under fibres under compression, showing that nature had proportioned them well to their work.

An important question that arises out of this inquiry is what shall be the proper scantling of timber and the span separating the poles on telegraph lines of varying number of wires.

In solving this problem we have not only to take into consideration the proper factor of safety to be allowed, and the wind pressure to be exerted upon the wires and the poles, but the fact that the diminution of spans beyond certain limits is impracticable owing to the injurious lowering of the insulation by the multiplication of supports.

The factor of safety is 4 and the maximum wind pressure per square foot is taken at 18·75lbs., reducing the effective area in the ratio of 10 to 6, owing to the circular section of the wires. We know very little of the average pressure on a long wire supported close to the ground. Most records have been made in exposed positions, and at consider-

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able heights, whereas the average height of a trunk line of wires is but 20ft. above the surface. The President of this Section (Mr. Baker) thinks 30lbs. per square foot a fair average to take for telegraph wires, but considering the frictional resistance of the ground and the obstructions due to hedges, banks, walls, trees, &c., I am inclined to consider this too high. We have usually taken 18·75lb. per square foot as a fair measure of the wind pressure on our wires, and the results of practice very much confirm this view.

Table III. has been drawn up showing the strength of round poles one foot long, and varying in diameter from 6 to 13½in. To obtain the strength of any pole it is only necessary to divide the tabulated breaking strain by the length of the pole in feet.

TABLE IV.

WIND PRESSURE, 18·75 per sq. ft.—*factor of safety of* 4 : STRAINS AND STRENGTH *of* 17 *wire line; 60 yards spans; calculated to constants obtained at Gloucester-road:—*

Length of pole.	No. 8 wire.		No. 14 copper.		Present specifn. diameter.
	Moment of pressure in lbs.	Safe diameter.	Moment of pressure in lbs.	Safe diameter.	
26	8344·0	8·25	3953·6	6·0	8·25
28	9374·4	8·5	4446·4	6·5	8·75
30	9811·2	8·5	4648·0	6·75	9·0
32	10796·8	8·75	5118·4	7·0	9·25
34	11771·2	9·25	5577·6	7·25	9·75
36	12264·0	9·25	5790·4	7·5	10·0
40	14224·0	9·75	6742·4	7·5	10·75

TABLE V.

WIND PRESSURE, 18·75 per sq. ft.—STRAINS AND STRENGTH *of 20 wire line: 60 yards span: Calculated on Constants obtained at Gloucester-road.*

Length of pole.	No. 8 wire.		No. 14 copper.		Specification diameter.
	Moment of pressure in lbs.	Safe diameter.	Moment of pressure in lbs.	Safe diameter.	
26	9811·2	8·5	3953·6	7·5	8·25
28	10964·8	9·0	5196·8	8·0	8·75
30	11547·2	9·0	5465·6	8·0	9·0
32	12700·8	9·25	6014·4	8·5	9·25
34	13854·4	9·5	6563·2	8·5	9·75
36	15545·6	10·0	7369·6	9·0	10·0
40	16732·8	10·25	7907·2	9·5	10·75

The strength of the timber being satisfactorily settled, and a maximum wind pressure and factor of safety having been accepted, the length of spans for varying lines is readily calculated. Tables IV. and V. give the stresses on 17 and 20 wire lines, so arranged as to fulfil the implied conditions.

The experiments and calculations in this paper were done by Mr. Andrew Bell and Mr. James Gavey, of the Post Office Telegraph Department.

THE RELATIVE MERITS OF IRON AND COPPER WIRE FOR TELEGRAPH LINES.*

BY W. H. PREECE, F.R.S.

Copper is gradually replacing iron for aerial telegraphs, owing to its greater durability in the atmosphere; but its greater cost has led to the use of smaller-sized wires. This can be done without detriment to the economy of the line, for the resistance of copper, as compared with iron, varies very nearly inversely as its price per ton, and hence the cost per mile remains about the same. Hitherto only short lengths have been erected in smoky towns and through districts where chemical industries filled the air with gases destructive to iron wires; but the Post Office Telegraph Department has recently erected a No. 14 copper wire, ·080in. in diameter, weighing 100lb. per mile, all the way from London to Newcastle, 278·08 miles in length, and it became desirable to measure very accurately its electrical elements, so as to see if it possessed, as was anticipated, any marked advantage as a telegraph line over the galvanised iron wires hitherto used.

There were two series of experiments made. In the *first* series the relative electrical condition of the two kinds of wires was determined, and in the *second* series their relative rates of working.

The first series, the results of which are given in Tables I., II., III., and IV., was divided into two parts, the one consisting of tests made from Bishop Auckland to Teams, near Newcastle, a distance of 30·235 miles on the north side, and to Pierce Bridge, a distance of 9·172 miles on the south side, and the other consisting of tests of a section of line between Pierce Bridge and Baldersby Cross Roads, 26·7 miles in length. The poles carried 10 wires. The tests were made in dry and favourable weather by Messrs. Kempe and Eden.

The electrostatic capacity of an aërial line is known to vary as

$$\log \frac{4h}{d}$$

where h is the height of the wire above the ground, and d its diameter. Now, the average height of the copper wire on the sections between Bishop Auckland and Teams and between Pierce Bridge and Baldersby Cross Roads is 23ft., and that of the iron wire (on a lower arm of the pole) 22ft., their diameters being ·080in. and ·171in. respectively. We have, therefore, for copper wire

$$\log \frac{4h}{d} = \log \frac{4 \times 23 \times 12 \times 1000}{80} = 4{\cdot}1398791,$$

for iron wire

$$\log \frac{4h}{d} = \log \frac{4 \times 23 \times 12 \times 1000}{171} = 3{\cdot}7906678,$$

and

$$\frac{3{\cdot}7906678}{4{\cdot}1398791} = {\cdot}916 \text{ nearly},$$

which makes the capacity of the copper wire to be 100 – 91·6, or 8·4 per cent. less than that of the iron wire. This result agrees pretty closely with the mean value of the differences of capacity obtained by actual measurements on these sections—viz., 9·1 per cent.

For the Bishop Auckland-Pierce Bridge section we have:—

For copper wire

$$\log \frac{4h}{d} = \log \frac{4 \times 21 \times 12 \times 1000}{80} = 4{\cdot}1003705.$$

For iron wire

$$\log \frac{4h}{d} = \log \frac{4 \times 20 \times 12 \times 1000}{171} = 3{\cdot}7492751$$

and

$$\frac{3{\cdot}7492751}{4{\cdot}1003705} = {\cdot}914$$

making the capacity of the copper wire to be 100 – 91·4, or 8·6 per cent. less than that of the iron, whilst the actual value was found to be 9·7 per cent. The differences between the calculated and the experimental values are probably due to the influence of trees, buildings, &c., which cannot be allowed for theoretically. These measurements were made when the other wires on the poles were left insulated. The effect of having all the other wires to earth when the capacity of any one wire was measured was very marked. Thus, on one wire the capacity was increased from ·352 to ·451 microfarad, or 22 per cent. It would therefore appear that the mean capacity per mile of a single iron wire of ·171in. in diameter, placed about 20ft. above the ground, is ·0131 microfarad, while an iron wire of the same size, suspended at the same height, but surrounded by other wires forming telegraphic circuits, would have a mean capacity of ·0169 per mile. The capacity of copper wire of ·080in. diameter under similar conditions would be about ·0120 and ·0142 microfarad per mile respectively.

* A Paper read before the British Association at the meeting at Aberdeen.

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TABLE I.—*Tests of Copper and Iron Wires on Road Line between* BISHOP AUCKLAND *and* TEAMS TERMINAL POLE (19th July, 1885).

Designation of wire.	Material.	Gauge.	All wires disconnected except one on lowest arm. Capacity in microfarads.		All wires to earth except one under test. Capacity in microfarads.		Conductor resistance in ohms.		Insulation resistance in megohms.		Remarks.
			Total.	Per mile.	Total.	Per mile.	Total.	Per mile.	Total.	Per mile.	
No. 241	Copper.	14	·400	·0132	·436	·0144	278·7	9·21	2·709	81·9C	Weather fine; temperature 66° F. in the shade. Length of section tested 30·235 miles.
,, 242	Iron.	7½	·444	·0146	...	...	346·4	11·45	2·483	75·08	
,, 243	,,	,,	·458	·0151	...	...	345·0	11·41	1·146	34·65	
,, 330	,,	,,	·450	·0148	...	...	345·4	11·42	2·295	69·30	
,, 245	,,	,,	·447	·0147	...	...	345·6	11·43	·513	15·51	
,, 329	,,	,,	·447	·0147	·510	·0168	345·9	11·44	2·292	69·30	
Newcastle-Liverpool 3	,,	,,	·440	·0145	...	...	346·2	11·45	1·655	50·04	
Cardiff-Newcastle	,,	,,	·440	·0145	...	...	347·0	11·47	1·862	56·30	
Leeds-Newcastle 2	,,	,,	·461	·0152	...	...	346·7	11·46	1·862	56·30	
Manchester-Newcastle 2	,,	,,	·449	·0148	...	...	347·0	11·47	2·128	64·34	

TABLE II.—*Tests of Copper and Iron Wires on Road Line between* BISHOP AUCKLAND *and* PIERCE BRIDGE (19th July, 1885).

Designation of Wire.	Material.	Gauge.	All wires disconnected except one on lowest arm. Capacity in microfarads.		All wires to earth except one under test. Capacity in microfarads.		Conductor resistance in ohms.		Insulation resistance in megohms.		Remarks.
			Total.	Per mile.	Total.	Per mile.	Total.	Per mile.	Total.	Per mile.	
No. 241	Copper	14	·112	·0122	·128	·0139	85·9	9·36	5·730	52·56	Weather fine; temp. 66° F. in shade. Length of section tested 9·172 miles.
,, 242	Iron	7½	·125	·0136	...	...	116·5	12·70	4·515	41·41	
,, 243	,,	,,	·123	·0134	...	...	116·6	12·71	2·980	27·33	
,, 330	,,	,,	·127	·0138	...	...	114·9	12·52	4·655	42·70	
,, 245	,,	,,	·128	·0139	...	...	113·7	12·40	2·709	24·85	
,, 329	,,	,,	·128	·0139	·151	·0164	113·9	12·41	3·460	31·73	
Newcastle-Liverpool 3	,,	,,	·130	·0141	...	...	122·5	13·35	3·725	34·17	
Cardiff-Newcastle	,,	,,	·132	·0143	...	...	114·6	12·50	4·806	44·08	
Leeds-Newcastle 2	,,	,,	·132	·0143	...	...	113·7	12·40	4·515	41·41	
Manchester-Newcastle 2	,,	,,	·128	·0139	...	...	114·7	12·50	variable		All other wires disconnected when capacity of this was measured.

TABLE III.—*Tests of Copper and Iron Wires on Road Line between* PIERCE BRIDGE *and* BALDERSBY CROSS ROADS (26th July, 1885).

Designation of Wire.	Material.	Gauge.	All wires disconnected. Capacity in microfarads.		All wires to earth except one under test. Capacity in microfarads.		Conductor resistance in ohms.		Insulation resistance in megohms.		Remarks.
			Total.	Per mile.	Total.	Per mile.	Total.	Per mile.	Total.	Per mile.	
No. 241	Copper	14	·319	·0119	·377	·0141	243 5	9·12	1·488	39·732	Weather fine; temp. 76° F. in shade. Length of section tested 26·7 miles.
,, 242	Iron	7½	·345	·0129	...	...	327·8	12·27	·893	23·850 [variable]	
,, 243	,,	,,	·341	·0127	...	...	326·9	12·24	1·030	27·502	
,, 330	,,	,,	·342	·0128	...	...	326·6	12·23	·382	10·200	
,, 245	,,	,,	·351	·0131	...	...	326·5	12·23	1·116	30·973	
,, 329	,,	,,	·352	·0131	·451	·0169	327·2	12·25	·670	17·892 [variable]	
Liverpool-Newcastle 3	,,	,,	·361	·0135	...	...	326·9	12·24	·346	9·238	
Cardiff-Newcastle	,,	,,	·361	·0135	...	...	327·1	12·25	·670	17·892 [variable]	
Leeds-Newcastle 2	,,	,,	·350	·0131	...	...	326·8	12·24	·893	23·850	
Manchester-Newcastle 2	,,	,,	·350	·0131	...	...	327·3	12·25	·893	23·850	

As regards the induction between wire and wire tests the effects obtained were very slight, though their actual value was determined with comparative accuracy.

The second series of experiments were conducted between London and Newcastle, and were designed, as stated above, to test the working efficiency of the copper wire as compared with iron wires. They were conducted by Messrs. Chapman and Eden. The results of the numerous trials of speed with various arrangements of the apparatus are given in Tables V. and VI., and are summarised in Table VII.

It will be observed that copper shows a very decided superiority over iron, the speeds being as follow :—

	Copper.	Iron.	
Simplex working...	414	345	words per minute.
Duplex ,, ...	270	237	,, ,,

It is anticipated that the superiority of copper over iron indicated by these experiments will have a beneficial and economical influence on our telegraph system, and that its extended use will enable us not only to work better, but to

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TABLE IV.—*Tests of New North Road Wires between* PIERCE BRIDGE *and* BALDERSBY CROSS ROADS (26th July, 1885).

Induction between Wires.

Primary Current. Wires.	Induced Current. Wires.	Galvanometer Deflections. Divisions.	Equivalent in Micro-Coulombs.	Primary Current. Coulombs per sec.	Distance between Primary and Secondary Wires.	Remarks.
					in.	
Nos. 242 and 243	Nos. 330 and 245	20	·0892	·0456	12·8	Weather fine. Temp. 76° F. in the shade.
Ditto ditto	No. 329 and {Newcastle / Liverpool}	10	·0446	,,	24·0	Resistance of Galvanometer 6700ω.
Ditto ditto	{Cardiff / Newcastle} and {Leeds / Newcastle}	5	·0223	,,	36·3	Resistance of looped wires, 654ω.
Nos. 330 ,, 245	Nos. 242 and 243	20	·0892	,,	12·8	Resistance of battery (30 Daniell's cells), 150ω.
Ditto ditto	Nos. 329 and {Liverpool / Newcastle}	20	·0892	,,	12·8	
Ditto ditto	{Cardiff / Newcastle} and {Leeds / Newcastle}	5	·0223	,,	36·3	
No. 329 ,, {Liverpool / Newcastle 3}	Nos. 330 and 245	20	·0892	,,	12·8	(In each case the value of the induced current given is the mean of several measurements.)
Ditto ditto	Nos. 242 and 243	5	·0223	,,	36·3	
Ditto ditto	{Cardiff / Newcastle} and {Leeds / Newcastle}	20	·0892	,,	12·8	

TABLE V.—*Mean results of speed trials on copper wire between* LONDON *and* NEWCASTLE-ON-TYNE (July, 1885).

Experiment.	Sending power, Bichro. cells.	Current passing thro.' receiving instrument, in milli-amps.	Form of receiving apparatus.	Arrangement of coils.	Speed, words per minute. Simplex. to London.	Simplex. from Londn	Duplex. to London.	Duplex. from Londn	Compensating capacity in microfarads. Duplex.	Simplex.	Remarks.
A 1 to 4..	40	12·3	Wheatstone Weight receiver, resistance of coils 100ω each.	Series.	400	414	...	...	...	3·5 to 4	Weather fine, with occasional showers.
B 5 to 8..	,,	,,	,,	Quantity	400	414	...	...	...	12 to 16	
C 9 to 15.	,,	,,	,,	...	...	...	265	273	Newcastle 2·75 to 3 G.P.O. 5 to 5·25	...	
D 16 to 20.	,,	,,	Relay with coils similar to those in receiver. Receiver in "local" circuit.	Series	400	414	...	...	...	3·5 to 4	
E 21 to 25.	,,	,,	,,	Quantity	400	414	...	...	...	12 to 16	
F 26 to 32.	,,	,,	,,	...	...	...	265	273	As in **C**	...	
F F	,,	,,	As in experiments A, B, and C; but resistance coils and condenser inserted at York in order to make the copper and iron wires alike in resistance and capacity.	...	400	414	...	...	...	...	
G 33 to 40.	,,	,,	Post Office Standard relay, receiver in local circuit.	Series	340	350	...	...	...	4·5	
H 41 to 46.	,,	,,	,,	Quantity	340	350	...	...	...	14 to 18	
I 47 to 50.	,,	,,	,,	...	...	...	240	250	As in **C**	...	

Length of line..... 278·08 miles (including 17·08 miles of underground work).
Diameter of wire..... ·08in.
Resistance per mile ..... 9·1ω
Capacity per mile ..... ·0141 m.f.
Insulation resistance per mile varied from 3 to 30 megohms.

dispense with intermediate repeaters in many cases where, on long lines, they are now necessary.

The most interesting point, however, in connection with these experiments is that they apparently prove that the superiority of copper is not simply due to its smaller electrostatic capacity and resistance, but that it is more susceptible to

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TABLE VI.—*Mean results of speed trials on iron wire between* LONDON *and* NEWCASTLE-ON-TYNE (July, 1885).

Experiment.	Sending power, Bichro. cells.	Current passing thro. receiving instrument, in milli.-amps.	Form of receiving instrument.	Arrangement of coils.	Speed, words per minute.				Compensating capacity in microfarads.	
					Simplex.		Duplex.			
					to London.	from London	to London.	from London	Duplex.	Simplex.
K 50 to 57	40	12·3	Wheatstone Weight resceiver, resistance of coils 100ω each.	Series.	333	340	...	...	...	3·5 to 4 [(*a*)
L 58 to 65	,,	,,	,,	Quantity	333	340	...	...	...	12 to 16
M 66 to 76	50 ,,	6 to 15 ,,	,, ,,	Series. Quantity	350	....	...	...	...	(*b*)
O 79 to 82	40	12·3	Relay with coils similar to those in receiver, receiver in "local" circuit.	Series.	354	360	...	...	...	As in **K**
P 83 to 89	,,	,,	,,	Quantity	354	360	...	...	...	As in **K**
Q 90 to 95	,,	,,	,,	...	...	...	231	243	Newcastle 2·75 to 3·25 G.P.O. 5·25 to 5·5	...
R 96 to 105	,,	,,	Post Office standard relay, with receiver in local circuit.	Series.	300	310	...	...	...	...
S 106 to 112	,,	,,	,,	Quantity	300	310	...	...	...	...
T 113 to 120	,,	,,	,,	...	...	...	214	224	As in **Q**	...
N 77 & 78	,,	,,	Wheatstone receiver. Resistance of coils 100ω each.	...	...	...	231	243	As in **Q**	...

Length of line ..... 278·08 miles (including 6 miles of No. 14 copper wire, and 17·08 miles of underground work).
Diameter of iron wire. ·171in.
Resistance ,, 12·15ω per mile.
Capacity ,, ·0169m.f. per mile.
Average insulation resistance 20 megohms per mile.

REMARKS.—(*a*) Weather fine, with occasional showers.
(*b*) Various combinations of resistance and capacity tried.

TABLE VII.—*Comparative Speeds Obtained on Copper and Iron Wires Under Similar Conditions.*
(Summary of Tables V. and VI.).

Words per Minute.								Average Increase of Speed on Copper Wire.
Iron.				Copper.				
Simplex.		Duplex.		Simplex.		Duplex.		
To London.	From London.	To London.	From London.	To London.	From London.	To London.	From London.	
333	340	...	...	400	414	...	...	21 per cent.
...	...	231	243	...	...	265	273	11·36 ,,
354	360	...	...	400	414	...	...	11·40 ,,
...	...	231	243	...	...	265	273	11·36 ,,
300	310	...	...	340	350	...	...	11·31 ,,
...	...	214	224	...	...	240	250	11·19 ,,
				Mean result of all experiments				12· 9 ,,

rapid changes of electric currents than iron; for when the resistance and capacity of the copper and iron wires were equalised by the insertion of resistance coils and condensers, the speed on the former was not thereby diminished. Possibly the magnetic susceptibility of the iron is the cause of this. The magnetisation of the iron acts as a kind of drag on the currents. It is well known that telephones always work better on copper than on iron wires, doubtless for the same reason.

These experiments also show the high speed of working that is now attained by the Post Office authorities with the Wheatstone automatic apparatus. The following table gives an interesting *resumé* of the different stages of the progress made, and its rate of growth:—

1877	80	words per minute.
1878	100	,, ,, ,,
1879	130	,, ,, ,,
1880	170	,, ,, ,,
1881	190	,, ,, ,,
1882	200	,, ,, ,,
1883	250	,, ,, ,,
1884	350	,, ,, ,,
1885	420	,, ,, ,,

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THE TELEGRAPH CONFERENCE.

Owing to a desire to give as much of the proceedings of the British Association as possible in this issue, we refrain from commenting upon the differences of opinion which characterised the concluding part of the Conference at Berlin. The labours of the Conference have ended, and we shall be better able in another issue to view them in their completed state.

THE SIXPENNY TELEGRAM REGULATIONS.

On Wednesday the morning papers were authorised to publish an official communication embodying the regulations which are to come into operation with Sixpenny Telegrams on the 1st October. These regulations are substantially those we foreshadowed a fortnight ago, when we were able to give our readers a facsimile of the new telegram form, differing only in greater precision as to the counting of streets and names of places in towns. As to these, we are inclined to agree with *The Times* that some further concession may be called for, not so much to remedy an injustice as to remove ambiguity. It may be quite proper to count Ludgate Hill as two words and Malvern Wells as one, but the public will not think so; and what the public thinks right the public is sure to act upon, with resulting disputation and friction. It is rather hard at first sight to understand why, for example, Chester-le-Street should pass as one word while Chester-street must be paid for as two; or, to take a different case, why Lincoln's Inn Fields counts three, whereas Moorfields, of course, will be accepted as one. In strictness Street is a word distinct from its designation, just as much as Place, Terrace, Avenue or Square; but we shall be agreeably surprised if the pressure of public opinion, which in this instance would be genuine though rather unreasonable, does not compel the Post Office to add this concession to the many it has already vouchsafed for the sake of peace and quietness.

With that exception, the Rules are not only manifestly sound, but extremely liberal. With characteristic ingratitude the public press has expressed but lukewarm appreciation of the positive gains under the new Rules, whilst it instantly falls foul of the single and insignificant restriction. A probable explanation is that the advantages, though far more substantial, are not so obvious as the drawback. A little reflection, however, will show how enormous the advantages are. In the first place the sender is neither compelled nor invited to insert either his name or address. In many cases—the official communication on the subject says in most—he will save himself the expense of signalling these particulars, which he can generally do by altering the phraseology of his message, substituting his name for the personal pronoun, or by trusting to his indentity being recognised. These remarks apply to domestic messages chiefly; business men will adopt special methods of their own to which we need not particularly refer. Secondly, the names of all towns and villages, no matter how compounded or whether they occur in the text or address of the message, will count as one word. The same rule will apply to names of persons, that is to their surnames, though double-barrelled names of the Lane-Fox type and the like will have to pay for their singularity. Combinations of letters, such as those representing the London Postal Districts, the a.m. and p.m. representing morning and afternoon, the familiar f.o.b. and c.f.i., which in shipping business stand respectively for "free on board" and "cost freight and insurance," and all similar groups of not more than five letters, will be treated each group as a word. We may be sure that in practice the principle here recognised will be applied pretty freely by the public, and that the Post Office will give the benefit of the doubt to their customers in all cases not specifically met by the Rules.

But the most important concession of all is that which assimilates the inland method of counting figures with that of the Continent. Any group of figures, or symbols joined with figures, not exceeding five, will count as one word, instead of being charged separately as they are at present. The ordinary public will feel the benefit of this chiefly in the address, but frequently also in the hour of the day. Half-past twelve would count as three words, but it will go for a halfpenny if written 12:30. Similarly, amounts such as 2/7/6 are to be counted as one word. It is to be regretted that the symbol £ is not to be treated as a figure; but its equivalent can generally be represented by converting the pounds into shillings—thus 100/- will stand for £5. To the commercial community this alteration in the treatment of figures will be an immense boon; they are employed pretty largely even now, and very soon uses will be found for them to economise words to an extent which is perhaps little dreamed of at present.

On the whole, therefore, it will be seen that the regulations under which the reduced tariff is to be worked are quite in harmony with the principles on which the scheme was promoted. We never favoured the reduced rate; but we have always upheld the principle of charging for the addresses, and of conceding liberal rules in respect to counting as a set-off to the free addresses. If a Sixpenny Telegram scheme can be made to pay in the United Kingdom this one will pay, and we hope it may. But whatever its financial fate may be, we are quite sure that the fame predicted for the measure by *The Times* the other day was a piece of journalistic clap-trap. We were told that nobody cares for the Vote whilst everybody cares for the Telegraph, and that the Act which gives us Sixpenny Telegrams

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will be gratefully remembered when the Franchise Act is buried in well merited oblivion. We strongly advise the Post Office not to reckon on this public gratitude, any more than *The Times* seriously reckons on the futility of the county voter.

No comparison of these two things can be made except in a way that is flattering to neither. The Telegraph has taken its final plunge, and in that sense, perhaps, the incident may be memorable; whereas there remains for the Franchise some yet lower depths, in descending which the memory of this year's exploit will be effaced altogether. Our chief misgiving with regard to the former has been, not that it will be forgotten, but that in cheapening it we may be spoiling a very precious gift, taxing it with frivolous errands, and maiming its capabilities for matters of weight and moment. We can only hope that the energy and resources which have made British telegraphy the fastest and surest in the world may be able to avert the decadence which in other countries has overtaken the administration whenever cheapness and popularity have been sought at the expense of efficiency and speed.

CORRESPONDENCE.

DOUBLE POLE SWITCHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am somewhat at a loss to know what conclusion to draw from Mr. Killingworth Hedges' reply to my letter advocating the use of double pole switches and double pole safety cut outs.

He cannot mean to deny the utility of double pole fittings, because he says "*the double pole cut out has been found of service in preventing accidents*," also that the "*Boston Fire Underwriters' Union recommend a separate cut out to be placed on each wire*," and again, "*double pole switches may be advisable sometimes*."

In all this he has simply strongly endorsed my own views.

It certainly then seems to me that his letter narrows down to an expression (his own, let it be known) that *English electrical engineers would not profit by using American fittings.* The italics are mine, and I am sure that from the many sidedness of electrical science electrical engineers, of all men, will be the most free from insular prejudices, and will take up whatever is best.

The installation of the Edison Company in America where he did not find double pole fittings must decidedly have been some of the first put in. The only other part of the letter calling for serious comment is when he states *a short circuit may occur on the block itself between the fusible plugs.* I assert that this is practically impossible, and it has never been known to occur yet, although it might possibly have occurred in some of an inferior make of blocks that have been used in this country.

The double pole fittings of *Bergmann* have been used in only two or three installations other than our own, and all engineers under whose notice we have brought them have said they are the best things of the kind they have seen.

However I do not propose to carry on an argument with Mr. Hedges to no advantage.—Yours, &c.,

JNO. B. VERITY.

31 and 32, King-street, Covent Garden, W.C.,
September 14, 1885.

THE LIFE OF INCANDESCENT LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

"The most important table of the life of incandescent lamps ever published."

SIR: Confessing at the outset my utter and hopeless ignorance of the methods of computation adopted in the calculation of statistics referring to incandescent lamps, would Mr. Grundy kindly make clear how he arrives at the value of the average life of incandescent lamps by dividing the total lamp-hours for a short period by the number of lamps lost in that period?

To a non-mathematical mind like my own it would seem that if 500,000 lamps be run at a moderate efficiency for one hour, probably not more than 10 will be destroyed. If so, then $\frac{500{,}000 \text{ lamp-hours}}{10 \text{ broken lamps}}$ gives, on Mr. Grundy's method, 50,000 hours as the normal life. But we can obtain more than this. If we run these lamps for one minute the chances are not one will be lost if the cracked lamps have been eliminated, not even if the lamps are run at 1·5 watt per candle. Therefore, we should have $\frac{500{,}000}{6{\cdot}0} = 8{,}333$ lamp-hours $\frac{8{,}333}{0} = \text{infinity}$.

Therefore, the life of lamps at 1·5 watt per candle is infinite! Will Mr. Grundy kindly correct?—Yours, &c.,

London, S.E., Sept. 17, 1885. CARBON.

FACSIMILE TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the note in your last week's issue concerning a method of transmitting handwriting in facsimile by telegraph, it may be worth while noting that this "invention" is far from new. More than fifteen years ago I read a description of an exactly similar apparatus in a small work dealing with electrical matters, and published—if I may trust my memory—some twenty years ago.—Yours, &c.,

A. DALGLEISH.

57, Holborn-viaduct, London, E.C., 14th Sept., 1885.

[Our correspondent speaks of the principle, and not of an instrument. Our note referred to the latter. There are, of course, several methods by which handwriting can be transmitted in facsimile by telegraph.—ED. *E.*]

MANCE'S METHOD OF ELIMINATING POLARISATION;

ITS EMPLOYMENT FOR TESTING THE RESISTANCE OF THE HUMAN BODY.*

BY DR. W. H. STONE.

At the Southport meeting of the British Association I gave a short account of some observations tending to show that the resistance of the living human body to electrical currents was considerably—indeed, surprisingly—less than that usually given in works on medical electricity and physiology. Even such authorities as Rosenthal, in Germany, and Dolbear, in America, assigned values varying from 10 to 100 times the real figure. I produced evidence to prove that this was in the main due to imperfect contact between the body itself and the poles of the measuring instrument. By immersing the patient's extremities in saline solutions, and using large leaden electrodes, this initial error was eliminated, and a fair approximation to the real determination laid before the meeting.

But two secondary difficulties at once presented themselves, first, that the human body possesses considerable electrostatic capacity, and acts as a condenser; second, that it acts as a secondary battery, and sets up a very appreciable counter electromotive force.

In my Southport paper I described a method of alternating momentary contacts with a reversing key, by which the second of these difficulties was minimised. But even on this plan the later readings were always somewhat higher than the earlier, and the resistance seemed to rise slowly to a maximum. This was clearly counter electromotive force due to polarisation, and the resistance actually noted was the real resistance plus an indeterminable polarisation quantity.

So far at Southport. It was, however, then suggested to me to use the alternating current of an induction coil, and to replace the galvanometer by a telephone. At this latter method, which is extremely elegant, I worked steadily for the following year, and as I incidentally discovered that the alternating current of the induction coil introduced to physio-

* Paper read at the Aberdeen meeting of the British Association.

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logical research mainly by Du Bois Raymond had not been measured, I set myself this task, first by means of Kohlrausch's dynamometer, and, secondly, by a modification of Sir. W. Thomson's quadrant electrometer. But from the first the results by this method were so singularly discrepant from those I had obtained by the other that I suspected its accuracy.

For instance, in a very tall and athletic man, a student at St. Thomas's Hospital, the resistance from foot to foot was always about 1,000 ohms, but by this method never above 600 ohms. By Mance's method it comes out by two separate observations to be 1007·6 and 1009 ohms, a good result.

It became evident that there were two opposite causes of error, a condenser action spuriously lowering the reading specially strong with alternating currents and a polarisation fallaciously raising it very marked with continuous currents.

To ascertain the exact amount and proportion of either of these presented a task of no small difficulty, and one, indeed, at which I am still working. I hope fairly to complete it in time for the Lumleian lectures, which the Royal College of Physicians have requested me to deliver in the early part of next year.

It struck me that the human body, besides being an imperfect conductor, resembles a very leaky condenser—in fact, it has three attributes, it is a conductor, a condenser, and an electrolyte, and is not dissimilar to a faulty submarine cable.

On these points I consulted Mr. Latimer Clark, who referred me to a paper by Mr. Henry Mance, read before the Society of Telegraph-Engineers on May 8, 1884.*

By the kindness of Messrs. Clark, Muirhead, and Co., I have been able to procure one of Mance's beautiful instruments for exhibition at this meeting.

Mr. Mance very kindly assisted me with his advice, and corrected some of my early results, one of which is on the black board.

R_1 945·6	R_2 950·950	result 939	Foot to foot.
R_1 920·933	R_2 1040·1066	result 905·46	Foot to hand.

Now, if the resistance can thus be correctly obtained the subsequent work is much facilitated. I have already a few rough results, and am steadily increasing their number.

ELECTRIC LIGHTING AT FORTH BRIDGE WORKS.†

BY JAMES N. SHOOLBRED, B.A., MEM. INST. C.E.

In the summer of 1883, the contractors for this most important engineering work, Sir Thomas S. Tancred, Arrol, and Co., decided to make use of electricity in the illumination of the large works required for the preparation and construction of this large undertaking. The author was by them entrusted with the preparation of the necessary plans, together with the supervision of the arrangements to enable the lighting by electricity to be thoroughly and suitably carried out.

For the construction of the bridge, and the proper preparation of the large amount of steel which enters into it, very large workshops have been erected at South Queensferry, where also are concentrated the principal offices, central stores, canteen, &c. A steep incline conveys the materials from the height on which the workshops stand down to the shore of the Firth, the lines of way being then continued on a broad wooden jetty, 50ft. in width, projecting into the Firth for about 700 yards, up to the Queensferry main piers, whence springs the southernmost of the two large spans of the bridge.

The Island of Inch Garvie, situate in mid channel, with its group of workshops, offices, &c., necessary for the operations carried on at this isolated and exposed situation, forms the next spot requiring, at present, the use of the electric light.

On the northern, or Fife shore of the Firth, the operations about the Fife main piers, the northern end of the second of the large spans, together with the branch workshops, stores, &c., connected therewith, as well as portions of the land viaduct extending northwards, and a part of the large stone quarries and shipping stages in the vicinity thereof, are the spots requiring to be lighted by electricity.

The conditions to be fulfilled in the illumination of the above localities (owing to the ever-changing extent of the demands upon the lighting, and the variation in the position of each light—a matter which varied constantly with the progress of the work in its vicinity, with the state of the tide and from other causes) rendered it evident that the details of the arrangements for the lighting must be such as to allow of the requisite changes being effected readily and expeditiously.

Again, it was evident also that portions of the cables, wires, and other working parts of the lighting apparatus, would be constantly within reach of the workmen. The primary condition, therefore, demanded a system of lighting simple in its arrangements, and which would inspire confidence in the new illuminant among the workmen.

It became evident that while arc lights would be required for the outside, the offices, residential premises, stores, &c., demanded incandescent lights; and again, that other buildings, such as the large workshops, necessitated the use of both arc and incandescent lights. Also, that the use of storage accumulators, as well as the transmission of power by electricity, might be desirable.

To meet these various conditions it was decided—1st, to adopt continuous current machines; 2nd, that the type of dynamo for the outside arc lights, limited to six lights in series, should not have a greater E.M.F. than 300 volts between the terminals; 3rd, that the type of dynamo for the incandescent lights, or for the arc and incandescent lights used conjointly, should be on the compound-wound principle, with a maximum E.M.F. of 120 volts between the terminals. The incandescent lamps, in parallel series, used with these machines, to have an E.M.F. of 110 volts; while in the large workshops arc lamps in pairs (in series with one another, with the addition of a suitable resistance) would be used, where required, conjointly with the above incandescent lights.

Near to the large workshops are a number of parallel lines of rails, forming a large uncovered workshop, and termed the "Drill Roads." Upon these roads circulate large movable huts, each containing an engine, drilling machines, and a circular frame, intended for the formation of the various steel tubes of the bridge. Here, as in the large workshops, the use of both arc and incandescent lights is necessary. But, as the exact site where each kind of light might be wanted depended upon the whereabouts of the hut upon the rails, it became necessary to provide for this, at certain fixed spots, supply or "service" boxes, whence readily fixed flexible branch-mains lead the current to the desired site of the lights.

Tenders having been invited for the carrying out of the necessary works, all the lighting on the South Queensferry side was entrusted to and very efficiently carried out by Messrs. Siemens Brothers and Co., while the works on the north side and on Inch Garvie were executed in a very satisfactory manner by Messrs. R. E. Crompton and Co.

The electrical plant contained in the above installations may be stated briefly as thirteen dynamo machines, developing about 150 electrical horse-power; 100 large arc lamps (of 2,000 candles each); 500 incandescent lamps (of 20 candles each). A total length of about twelve miles of mains has been laid down in the various circuits, exclusive of branch wires to lamps. The lighting by electricity has been carried on continuously, and with satisfactory results for nearly two years, by means of the above arrangements. That the peculiar requirements of the situation, together with the storms of winter, have been successfully coped with attests the careful and thorough manner in which both of the well-known firms who executed the works performed the part entrusted to them.

During that period of working several points of interest have arisen, and among them the following:—

1st. The excessively varying conditions which are constantly occurring with regard to the outside arc lights, both as regards the number in actual use, and as to the exact position of each light (dependent greatly upon the character of the particular work going on in its vicinity, the state of the tide, &c.) have been satisfactorily met in the following manner:—The duty of each series machine was limited to six arc lights, as already stated, in order to avoid an excessive E.M.F., the actual number

* This method is described in the Society of Telegraph-Engineers' *Proceedings* last year.

† Paper read at the Aberdeen Meeting of the British Association.

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lighted being varied between one and six at will, by means of resistance frames. Furthermore, arrangements have been made on a general switch-board by which any of the circuits (sometimes as many as six in one locality) could be coupled with each other; so that the six lights or less, the complement of one machine, might be made to occur, if desired, over a circuit of very varied length (sometimes more than a mile long).

2nd. The lighting of the large workshops, the drill roads, &c., demanded a combination of arc and of incandescent lights, the relative proportions between the two kinds being subject to constant variations. It was also necessary that the position should be readily varied, and also that additional lights of either kind might be easily obtainable at will. The use of compound-wound dynamos with the lamps in parallel circuit (the arc lamps being in pairs, in series with each other, with a suitable resistance in addition) provided for the first condition, while the second was complied with by the use of "service-boxes," containing "plug sockets," into each of which was inserted the plug end forming the extremity of a certain length of flexible twin-leading wire, attached to each portable arc or incandescent lamp. The lanterns in which these several lamps were placed varied considerably in form—with arc lights for outside, or for workshop use—while for incandescent hand-lamps, reflecting bulls' eyes, divers' or miners' lanterns, &c., might be required.

The advantages attached to this mode of working lamps in parallel circuit have proved very considerable. The ease with which lights of either kind can be added to or diminished fn number, together with the comparatively low E.M.F. (110 volts), are points which must be appreciated by practical electrical engineers. At South Queensferry alone as many as 50 arc lights (or, in lieu, 600 incandescents) are being worked on this principle. Great credit is due to Messrs. Siemens on this head, for at the time of their first being used nothing on so extended a scale on the parallel system existed elsewhere, and certainly the working in pair series was quite unique.

3rd. Perhaps nowhere have more points of interest arisen than in the illumination of the working chambers of the deep water caissons, which were constructed to assist in getting in the foundations of the main piers. Each of these circular steel caissons, 60ft. in diameter, and rather more in height, has its sides projecting downwards for about 8ft. below the diaphragm or ceiling which extends across this part of the cylinder. The lower chamber which is thus formed is open-mouthed, and becomes a huge diving-bell. In it a number of workmen, having passed down from the surface through a tube 3ft. 6in. in diameter, excavate the bottom (passing the *débris* up another tube), and gradually sink the caisson to the requisite depth. This is, of course, done under air compressed according to the height of the water outside. In the caissons for the Queensferry main piers, where the bottom was of clay, the illumination was effected by means of Swan incandescent lamps, eighteen in number, of the ordinary 110 volt, 20 candle-power type used throughout the works, but each protected by a strong spherical wire guard for protection from any blow. They were pendant from the ceiling, hung on to a hook or wherever else required, each having a certain length of twin wire attached, terminating at the other end in a contact plug. The two gutta percha covered mains for conveying the electric current from the dynamo pass from the outer air into the air-lock chamber through a stuffing box, and thence down the descent tube into the working chamber, where they are led along the ceiling to a distributing box, and thence, when required, to a second or even a third box. These distributing boxes each consist of solid copper rods, kept sufficiently apart, and embedded in a wooden block, having a number of square openings in it, each opening exposing sufficient of the copper rods to allow of a good contact being made. This contact is effected by the insertion, when required, of the "plug-end," which is, at the extremity of the flexible lead, attached to each lamp, which, at the moment of insertion, automatically lights up. In the caissons at Inch Garvie a different mode of lighting had to be adopted, owing to the rocky bottom, which necessitated blasting, and the shock of which would, most probably, have shattered the incandescent lamps. Here three arc lamps (of the same type as on the surface) have been used on two circuits working in parallel (a resistance replacing the fourth lamp, which was not required).

Above each lamp in the ceiling is a sort of hood, into which it is entirely drawn during blasting operations, in order to avoid any damage. A small pipe in the top of this hood leads off the products of combustion into the vertical shaft, and so into the air-lock, whence they are discharged into the air.

The firing of the dynamite charges is performed from the same dynamo which does the lighting. A special pair of mains are carried from the dynamo down the descent shaft to a distributing box on the ceiling of the working chamber. The arrangement of the plugs, &c., is the same as for the incandescent lamps—a firing fuse of a very simple construction replacing the incandescent lamp. At the top of the descent shaft the two mains are both secured and kept permanently in that state. By means of a peculiar double-contact maker connection can be made instantaneously. When everything is ready for firing, the foreman, who alone has access to the box where is the contact maker, fires readily the number of charges that may be required. A great deal of the successful working of the lighting arrangements in the caissons, as also in other parts on the surface, is due to the ingenuity and assiduous attention of Mr. Sydney Baynes, the resident electrician at the Forth Bridge Works.

The preceding gives a brief description of the general arrangements which have been in use, so far, for the lighting, not merely of what may be termed the comparatively permanent part of the works (such as the offices, stores, workshops, &c.), but also for the actual operations of the foundations of the bridge itself. Shortly this stage will be at an end, and the erection of the superstructure will necessitate probably far different arrangements—lights scattered considerably, and of a very portable character. Then may, perhaps, come into play, as valuable adjuncts, these two other applications of the electric current—its utilisation in connection with storage accumulators, and for the transmission of power, objects the possibility of the future use of which led the author to adopt continuous current dynamo machines for the lighting by electricity of the Forth Bridge Works.

THE GENERATION OF A VOLTAIC CURRENT BY A SULPHUR CELL WITH A SOLID ELECTROLYTE.*

BY SHELFORD BIDWELL, M.A., LL.B.

So far as I am aware there has never yet been constructed a voltaic cell having a solid electrolyte which, at least at ordinary temperatures, would produce the smallest indication of a current in the most delicate galvanometer. Sir William Thomson has described† a cell consisting of a piece of flint glass between plates of zinc and copper. After the glass had been warmed to 50° C. the plates were found to give indications of the existence of an electromotive force when connected with an electrometer. Profs. Ayrton and Perry have made similar experiments,‡ using paraffin wax, gutta percha, india rubber, and shellac. But it is needless to say that with electrolytes of such enormous resistance as these, no current could be generated which could be detected in the ordinary way by any galvanometer, however sensitive.

The present paper contains an account of some experiments with cells in which the electrolytes consisted of sulphides of silver and copper between plates of the same metals. In nearly every case these arrangements were found to be capable of generating sensible currents, which sometimes, indeed, measured several thousand micro-amperes, and were capable of producing deflections in coarse galvanometers with pivoted needles. Some of the results obtained are curious and even opposed to what might have been expected, but they will in general be given without any comment or attempted explanation. The copper and silver plates used were in every case 3 cm. square.

(1). A cell was made by compressing a thin layer of

* Paper read before the British Association, at Aberdeen, 1885.

† *Proceedings* Royal Society, 1875, XXIII., p. 463. ‡ *Ibid*, March 21, 1878, p. 222.

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powdered silver sulphide between plates of silver and copper. When connected with a shunted reflecting galvanometer the cell produced a deflection indicating a current of about 30 micro-amperes. The direction of the current was from copper through sulphide to silver. On the following day, the circuit having been open in the meantime, the cell generated a current of only four micro-amperes. The copper plate was found to have acquired a purple colour; the silver was untarnished.

(2). The same cell was charged with equal parts of silver sulphide and sublimed sulphur mixed together. It now gave a current in the same direction of about 1·5 micro-ampere.

(3). A layer of precipitated copper sulphide was placed between plates of copper and silver, which were squeezed together in a screw press. When connected with the galvanometer (unshunted) this arrangement produced no deflection whatever.

(4). The cell was recharged with a mixture of two parts of copper sulphide with one part of sulphur, and when connected with the galvanometer it was found to give a very small current from *silver to copper*, indicated by a deflection of two or three scale divisions. The deflection was reversed as often as the connections with the binding screws of the cells were reversed, and the existence of a small electromotive force was undoubted. The internal resistance was ·088 ohm.

(5). Sufficient sulphur was added to the mixture to bring the resistance up to 2,700 ohms. The cell, when remade, produced a galvanometer deflection which was at first about 100 divisions (indicating a current of ·08 micro-ampere), but soon increased somewhat irregularly to 250 divisions. The direction of the current was, as before, from silver to copper through the cell.

(6). A plate of copper was heated, and upon it was spread a mixture consisting of five parts sulphur and one of copper sulphide. A plate of silver, previously heated, was laid upon the melted mixture and the two plates pressed together. The thickness of the sulphur mixture between the plates was 3 mm. When this cell, after cooling, was connected with the the galvanometer, the spot of light was at once deflected off the scale. Dr. Fleming was kind enough to make a very accurate measurement of its electromotive force by comparison with one of his standard Daniell cells. It was found to be ·0712 volt, and its internal resistance was 6,537 ohms.

(7). A similar cell was made with a mixture of equal parts of sulphur and copper sulphide. Its internal resistance was much lower, being only 13 ohms, but its electromotive force was also lower, being ·007 volt. This result agrees with those of (3) (4) and (5) in showing that the electromotive force is diminished when the proportion of sulphide to sulphur is increased.

(8). Another cell was made in the same manner as the two last described, but the sulphur was mixed with silver sulphide instead of with copper sulphide. This gave a strong current in the same direction as that produced when copper sulphide was used, and opposite to the direction of the current generated by the cells (1) and (2). This reversal of the current may be accounted for by the fact that copper sulphide is formed when the melted mixture of sulphur and silver sulphide is brought into contact with the hot copper plate.

(9). In order to ascertain whether sufficient sulphide to maintain a current could be formed entirely in this manner, pure sulphur was melted on a clean plate of copper, and, when just liquid, a warmed plate of silver was laid upon it, and pressed down by a weight until cold. The cell gave a strong current from silver through sulphur to copper.*

(10). Thinking that the function of the free sulphur (without which, as has been seen, copper sulphide is incapable of generating a current) might be to form silver sulphide by contact with the silver plate, I constructed a cell as follows:—A thin layer of copper sulphide was spread upon a plate of copper, a polished steel plate was laid upon the sulphide, and the whole was strongly compressed in a vice. The steel plate was then removed, and a thin layer of silver sulphide was spread upon the smooth surface of the copper sulphide. The cell was completed by pressing a silver plate upon the silver sulphide. It gave a current of 240 micro-amperes through an external resistance of 3·5 ohms, the direction through the cell being from silver to copper. This form of sulphide cell seems to be exactly analogous in its action to a Daniell cell, consisting of plates of zinc and copper in solutions of zinc sulphate and copper sulphate. The quantity of the copper sulphide would be gradually diminished, copper being deposited upon the copper plate, while the quantity of silver sulphide would continually increase with consumption of the silver plate.

A similarly constructed cell with plates 2½in. by 2in. gave a current of 2,500 micro-amperes through an external circuit of ·5 ohm.

(11). Certain indications led me to believe that the cell last mentioned was short-circuited, and it appeared possible that this might be due to the penetration of particles of copper sulphide through the silver sulphide. The silver plate was therefore removed from the cell, and after being brushed over with a weak solution of sulphur in bisulphide of carbon, it was heated over a gas flame, and soon became covered with a perfectly uniform and continuous coating of sulphide. The heating was continued until all the free sulphur was driven off. When the cell was remade with this prepared plate it generated a current of 6,800 micro-amperes through an external circuit of ·2 ohm. The cell was found able to produce deflections in a roughly made galvanometer with a pivoted needle. Its electromotive force was ·05 volt, and its internal resistance, therefore, was about 7 ohms.

Experiments with other metals would probably lead to the construction of a sulphur cell of greater power than any of those described in this paper. Silver may, indeed, be the best or only possible metal for the positive plate, but it is by no means certain that the copper of the negative plate might not be advantageously replaced by some other metal.*

* A thin layer of sublimed sulphur was compressed between *cold* plates of silver and copper, which were connected with the galvanometer. A deflection of three divisions was produced, indicating a minute current from silver to copper. The experiment was repeated several times with the same result. (Moisture in the sulphur would have caused a current in the opposite direction.) This effect can, I think, only be explained by supposing that sulphides were formed in small quantities and diffused through the sulphur; but little importance can at present be attached to it.

ON THE SENSITIVENESS TO LIGHT OF SELENIUM AND SULPHUR CELLS.†

BY SHELFORD BIDWELL, M.A., LL.B.

The fact, first announced by Mr. Willoughby Smith in 1873, that the electrical resistance of crystalline selenium is temporarily diminished by the action of light has been fully confirmed by subsequent experimenters.‡ Mr. Smith's original piece of selenium was in the form of a rectangular plate, having electrodes of platinum wire fused into the shorter ends. Others have used the substance in the form of rods or bars similarly furnished with wires, but since the effective action of light is mainly limited to the surface exposed to it, and since the specific resistance of crystalline selenium is always very high, various more or less complex arrangements have from time to time been devised for the double purpose of obtaining as large a surface as possible relatively to the volume of the selenium used, and at the same time reducing the distance between the electrodes to the smallest practicable limit. To these devices the name of "cells" is now generally given; but it will be convenient to include in this term any arrangement, however simple, in which two metallic electrodes are connected together by a mass of crystalline selenium.

* In a paper recently communicated to the Physical Society, which will be published in its *Proceedings*, and also in the *Phil. Mag.*, experiments are quoted showing that the action of light *diminishes* the current generated by these sulphide cells, while heat increases it. Some very curious polarisation effects are also described.

† Paper read before the British Association at Aberdeen, 1885.

‡ Willoughby Smith, *Jour. Soc. Tel. Eng.* II, p. 31; Earl of Rosse, *Phil. Mag.*, March, 1874, p. 161; Sale, *Proc. Roy. Soc.*, 1873, p. 283; *Phil. Mag.*, March, 1874; Werner Siemens, *Phil. Mag.*, Nov. 1875, p. 416; Draper and Moss, *Chemical News*, XXXIII., p. 1; Adams and Day, *Proc. Roy. Soc.*, 1876, p. 113., *Phil. Trans.*, 1877, p. 313; C. W. Siemens, *Proc. Roy. Inst.*, 1876, p. 68; Sabine, *Phil. Mag.*, June, 1878, p. 401; Graham Bell, *Nature*, XXII., p. 500; Shelford Bidwell, *Proc. Roy. Inst.*, March 11, 1881, *Phil. Mag.*, April 1881, January 1883, and August 1885; Fritt's *Electrical Review*, March 7, 1885, p. 208.

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Of the many investigations which have been undertaken in reference to this subject by far the most valuable and exhaustive are those of Prof. Adams and Mr. R. E. Day, an account of which was published in 1876-7. From their paper in the *Philosophical Transactions** the following conclusions are abstracted :—

1. On exposure to light while a battery current is passing through it the electrical resistance of a piece of selenium is apparently diminished. Experiments with a Bunsen flame, with weak sources of light, and with moonlight, seem to show that this effect is due to the illuminating power rather than to the heating effect of the source.

2. The apparent change in the electrical resistance is directly proportional to the square root of the illuminating power of the light.

3. A slight increase of temperature of a piece of annealed selenium is accompanied by a large increase of electrical resistance.

4. There is on the whole a general diminution of resistance as the battery power is increased.

5. The first current sent through the selenium causes a more or less permanent "set" of the molecules, in consequence of which the passage of the current during the remainder of the experiments is more resisted in that direction than it is in the opposite one.

6. The passage of the current in any direction at any period of the series of observations produces a slight "set" of the molecules, which tends to facilitate the subsequent passage of a current in the opposite, but obstructs one in the same direction.

7. After the current from a voltaic battery has been passed for some time through the selenium, and when the electrodes have been disengaged from the battery and connected with a galvanometer, a polarisation current in the opposite direction to that of the battery is found to pass through the galvanometer.

8. Under certain circumstances the action of light is capable of developing an electromotive force in pieces of selenium through which a battery current has never been passed. Currents due to this electromotive force are called by the authors *photo-electric* currents.

With regard to the action of light in producing these photo-electric currents, and also in diminishing the resistance of a piece of selenium through which a battery current is passing, Messrs. Adams and Day have suggested the following explanation :† "Light, as we know, in the case of some bodies tends to promote crystallisation, and when it falls on the surface of such a stick of selenium tends to promote crystallisation in the exterior layers, and therefore to produce a flow of energy from within outwards, which, under certain circumstances, appears in the case of selenium to produce an electric current. The crystallisation produced in selenium by light may also account for the diminution in the resistance of the selenium when a current from a battery is passing through it. For in changing to the crystalline state selenium becomes a better conductor of electricity."

Others of their observed results led them to the conclusion that selenium conducts electrolytically,‡ but it may be inferred from the paper—and was, indeed, expressly stated by Prof. Adams at the meeting of the Physical Society on June 13 last—that the authors did not suppose that actual electrolysis occurred, but rather that the molecular structure or crystalline condition of the substance was altered or modified by the action of a current of electricity in such a manner as to produce effects analogous to those which would have occurred if the selenium were an electrolyte and actually decomposed by the current.

As regards the effect of temperature, the author's conclusion that a slight rise of temperature greatly increases the resistance of selenium appears at first sight to be inconsistent with the results obtained by Werner Siemens, Draper, and Moss, and others who found that the resistance of selenium was diminished by heat. But Adams and Day appear never to have submitted their selenium to a higher temperature than 30° C., and some experiments of my own, made with several different specimens,* revealed the curious fact that selenium cells, whether in the dark or exposed to light, have a temperature of maximum resistance which is generally a few degrees higher than the average temperature of the air. The observations of Messrs. Adams and Day are therefore not necessarily inconsistent with those of others.

At the meeting of the American Association held last year at Philadelphia, a paper was read by Mr. C. E. Fritts, descriptive of a new and very ingenious form of selenium cell, which is said to exceed any previously made, both in sensitiveness to light and in the power of the "photo-electric" current which it is capable of generating.†

He melts a thin film of selenium upon "a plate of metal, with which it will form a sort of chemical combination. . . . . During the process of melting and crystallising the selenium is compressed between the metal plate upon which it is melted and another plate of steel, or other substance with which it will not combine. . . . . The non-adherent plate being removed after the cell has become cool, [he] then covers that surface with a transparent conductor of electricty, which may be a thin film of gold leaf. . . . . The whole surface of the selenium is therefore covered with a good electrical conductor, yet is practically bare to the light which passes through the conductor to the selenium underneath."

Upon reading this description it occurred to me that the conduction of selenium when prepared in the form of cells might be in reality, and not merely in appearance, electrolytic. It will be noticed that Mr. Fritts spreads his selenium upon "a plate of metal with which it will form a sort of chemical combination." Now, selenium will, I believe, combine more or less readily with all metals, the combination being assisted by heat. And in the preparation of selenium cells it has been the usual, if not the universal, custom to submit the selenium to prolonged heating while in contact with metallic electrodes. This operation has hitherto been called "annealing," and the undoubted fact that it diminishes the resistance of the selenium and increases its sensitiveness to light has been explained by supposing that the process is favourable to perfect crystallisation. I have recently suggested,‡ as an alternative explanation, that the prolonged heating by promoting the combination of the selenium with the metal of the electrodes results in the formation of a selenide, which completely surrounds the electrodes, and is perhaps diffused to some extent throughout the selenium when it is in a liquid condition; and that the apparently improved conductivity of the selenium, together with the electrolytic phenomena which it exhibits are to be accounted for by the existence of this selenide. I found that while the specific resistance of the selenium contained in a good cell having copper electrodes was ·9 megohm, that of a similar piece of selenium annealed in a glass mould without contact with any metal was as much as 2,500 meghoms.§ This enormous difference must, I think, be attributed to the presence of selenide of copper in the selenium of the cell.

I do not know whether, when the electrodes are of platinum, which was the metal used by Adams and Day, any appreciable quantity of selenide would be formed at the temperature employed for annealing. But a very small proportion of an electrolyte would account for the observed phenomena, and it is not impossible that a sufficient quantity might be contained as an impurity in the selenium as supplied by the manufacturer. Prof. Graham Bell, who collected various samples of selenium from different parts of the world, found amongst other impurities iron, lead, and arsenic,‖ all of which would form conducting selenides. He adds, it is true, that when these impurities were eliminated the selenium appeared to be more constant in its action and more sensitive to light; but it must be remembered

* *Philosophical Transactions*, Vol. 167, p. 328.
† *Proceedings* Royal Society, 1876, p. 117.
‡ *Phil. Trans.*, Vol. 167, p. 328.

* *Phil. Mag.*, April, 1881, and January, 1883.
† *Proc. American Assoc.*, 1884. Reproduced in the *Electrical Review*, 7th March, 1885, p. 208.
‡ *Phil. Mag.*, August, 1885.
§ This was the result of a single experiment. The properties of selenium sometimes vary so greatly under apparently similar treatment that the conclusion should be received with caution.
‖ Paper read before the National Academy of Sciences, April 21, 1881.

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that in constructing his cells he always melted the selenium upon electrodes of brass or copper. "All former experimenters," he says*, "seem to have used platinum for the conducting part of their selenium cells, except Werner Siemens, who found that iron and copper might be employed. We have also discovered that brass, *although chemically acted upon by selenium*, forms an excellent and convenient material; indeed, we are inclined to believe that the chemical action between brass and selenium has contributed to the low resistance of our cells by forming an intimate bond of union between the selenium and brass."

I am not sufficiently versed in chemistry to be able to submit the hypothesis here suggested to the test of direct experiment. But certain indirect evidence in support of my views has been forthcoming. Selenium is an element which in its properties closely resembles sulphur, and attempts have from time to time been made, hitherto without success, to develop in sulphur that peculiar sensitiveness to light which is such a remarkable characteristic of selenium. It occurred to me that if this property of selenium were really due to the accidental existence of metallic selenides, then the admixture with sulphur of metallic sulphides might be expected to lead to similar effects. Several cells were therefore constructed in which selenium was replaced by sulphur containing a proportion of silver sulphide, the electrodes being formed of silver wire, and they all turned out to be more or less sensitive to light.† When one of these cells was connected in circuit with a battery and a galvanometer, and a piece of magnesium wire was burnt at a short distance from it, the galvanometer deflection was instantly increased, being in some cases more than doubled, and when the light was extinguished the deflection immediately fell to nearly its original value. If a telephone was substituted for the galvanometer, and the cell exposed to a rapidly interrupted beam of light, the telephone at once gave out a musical note which was nearly as loud as that produced when a good selenium cell was used.

The resistance in most of these cells was diminished by heating, and a number of experiments were therefore made for the purpose of ascertaining whether the effects described above were due to the direct action of radiation or to the rise of temperature by which exposure to radiation is accompanied. It was conclusively proved that the direct action of radiation was in itself competent to produce the effects. Firstly, the diminution of resistance due to light was instantaneous, while that produced by heating the cell was gradual. Secondly, the interposition of a glass trough containing a saturated solution of alum made no great difference in the result. Thirdly, a rise of temperature sufficient to produce any sensible effect could not possibly have been caused by the amount of light which was able to diminish the resistance in a marked degree. This was proved by the following experiment:—On a cloudy day the cell with the alum trough before it was placed at a distance of 16ft. from a small window, all the other windows in the room being darkened. With a battery of one Leclanché cell and a reflecting galvanometer it was found that closing the window shutter caused an instantaneous swing of the spot of light through ninety scale divisions in the direction indicating increased resistance; and when the shutter was again opened there was immediately an equal swing in the opposite direction. A delicate thermopile, connected with a galvanometer of low resistance, was then put in the place of the sulphur cell. On opening the window shutter a deflection occurred indicating a current which was found by trial to be equal to that produced by the radiation of the human body at a distance of 10ft. 6in. Now a nearly red hot brass rod held at a distance of little more than an inch from the cell produced a gradual fall of the resistance which in 15 seconds was indicated by only twenty-three scale divisions, and it is needless to say that the heat communicated by the human body at 10ft. 6in. was entirely without visible effect. Lastly, in the case of one cell (which contained sulphur and silver sulphide in equal parts) light and heat produced opposite effects. A paraffin lamp at a distance of 18 inches diminished the resistance. When the lamp was placed at a distance of 10 inches, the galvanometer needle first moved in the direction indicating a further fall of resistance, but after a few seconds, when the temperature began to rise, it turned in the opposite direction. On moving the lamp to a distance of 4 inches from the cell, there was at once a large deflection, indicating increased resistance, the temperature effect completely predominating over that of radiation.

When, as in the case of these cells, a current of electricity passes between silver electrodes through a mass of sulphide of silver, silver will be deposited upon the cathode and sulphur upon the anode. Now, sulphur has an enormously high resistance, and the existence of a mere film of free sulphur upon one of the electrodes would be sufficient to stop the current altogether. The current is not in fact stopped, because the deposited sulphur at once combines with the silver of the anode, merely adding a new layer to the electrolyte. Thus the metal of the anode gradually combines with the sulphur of the eloctrolyte, and the conductivity of the arrangement will depend to a great extent upon the facility with which this combination is effected, the quantity of electricity which can pass in a given time being limited by the quantity of sulphur which is capable of uniting with the electrode in the same time.

Sulphur combines with silver far more readily than with iron. If, therefore, my views are correct we should expect a cell with an iron anode to offer a much greater resistance than one which had an anode of silver, the material of the cathode, so long as it was a good elementary conductor of electricity, being of comparatively little importance. To test this idea a cell was made consisting of electrodes of iron and silver imbedded in a mixture of sulphide of silver and silver. The cell being connected with a battery and a galvanometer, it was found that its resistance was nearly thirty times as great when the current passed from iron to silver as when the direction of the current was from silver to iron.

It might therefore be expected that the resistance of a sulphur cell with silver electrodes would be diminished by any influence which assisted the combination of silver with sulphur. Experiment seems to show that such an influence is exerted by light.

A glass plate covered with silver leaf was placed, with the silvered side downwards, over a crucible of boiling sulphur. One half of the plate was covered with a piece of black cloth, and the arrangement was exposed to bright sunshine. In a short time the visible portion of the silver was darkened, owing to its partial conversion with sulphide; the cloth was then removed, and the silver beneath it was found to be scarcely discoloured.

Since this effect might possibly have been due to other causes than the action of light (such as the unequal condensation of sulphur-vapour upon the covered and uncovered portions of the plate), the experiment was made in another form. A piece of silver-leaf attached to glass was brushed over with a solution of sulphur in bisulphite of carbon, and, in order to keep the temperature low and uniform, the silvered glass plate was immersed in a basin containing cold water, which was placed in the sunshine.

A board was laid across the top of the basin so as to shade one half of the plate, the other half being exposed to the direct rays of the sun. In a quarter of an hour the exposed portion of the silver had acquired a dark brown colour, while that which had been protected was of a pale yellow tint, the outline of the shadow of the board being sharply defined. I think we have here the strongest evidence that the combination of sulphur with silver is assisted by light.

But it is not perhaps necessary to assume that the effective action of light is confined entirely to the electrode. It seems reasonable to suppose that any circumstances which are favourable to the union of two substances when they have a tendency to unite would also be favourable to their separation when from any cause they have a tendency to separate. If, then, as is commonly supposed, electrolysis involves a series of decompositions and recompositions, both these processes

* *Nature*, XXII., p. 502.

† Several different forms of these cells are fully described in a paper recently communicated to the Physical Society, and published in the *Phil. Mag.* for August, 1885.

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would be assisted by the same agency which under ordinary conditions favours the union of the constituents of the electrolyte. The electrolysis of silver sulphide may therefore be assisted by light, and its electrolytic resistance at the same time diminished.

All the sulphur cells hitherto mentioned were made with silver sulphide and silver electrodes. Silver was in the first instance chosen as being especially suitable for the purpose on account of the facility with which it combines with sulphur. A few experiments have since been made with copper and copper-sulphide, but no indication of sensitiveness to light has yet been obtained with these materials, though I do not consider the results conclusive. But even if it should turn out to be the case that silver is the only metal which in conjunction with sulphur is capable of forming a combination sensitive to light, it would still, I think, remain probable that the action of light upon the resistance of selenium, in conjunction with any metal whatever with which it formed a sensitive combination, is of a similar nature to that which occurs in the case of sulphur and silver.

ON ATMOSPHERIC ELECTRICITY.*

BY PROF. C. MITCHIE SMITH.

The commonly-accepted opinion that during fine weather the air-potential is always positive is not accurate for Madras. There it is found that with a dry land wind (*i.e.*, westerly wind) the potential of the air is usually negative during several hours of the day. In the early morning and up to about 9 a.m. the potential is usually positive, then it becomes negative, reaching a maximum between 10 and 11 a.m., and continues negative till the sea breeze sets in in the afternoon. During the prevalence of land winds there are frequent local showers, but these are evidently not the cause of the negative readings. Negative readings are never obtained in fine weather, except when the wind is westerly, and not even then unless the ground is dry. A shower of rain, which cools the ground, makes the succeeding readings positive for some hours. A marked feature during the prevalence of land winds are the great clouds of dust which fill the air, and it seems probable that there is some connection between these dust clouds and the negative electrification of the air.

TESTING KEYS.

Every electrician who has had much to do with the testing of submarine cables or with laboratory experiment has doubtless grumbled on occasion at certain of his apparatus. The Bavarian, reversing, testing keys and the galvanometer short-circuiting key now in use are especially deficient. The reversing keys give a great deal of trouble at times by failing to make good contact between line or earth and battery through the loosening of the cam usually employed to hold the lever, whichever it may be, down. A key we have lately had the pleasure of inspecting, however, seems admirably calculated to remedy this difficulty. The cam is dispensed with altogether, and a spring latch is introduced which when the lever is depressed, automatically catches and holds it with certainty in position until it is released by pressing the ebonite knob on the insulating pillar, as shown in our illustrations. The movement, either in depressing the lever or releasing it, can of course be easily effected with one hand. The advantages of this key, which is the invention of Mr. Pell, well known in connection with the Eastern Extension Telegraph Company, will be readily appreciated by all electricians. The absence of the cams and their supporting pillars, besides improving the insulation and allowing of the key being more easily cleaned, makes it look neater, and prevents the lacquered surface of the brass work being disfigured, as is invariably and unavoidably the case when the cams are used. A short-circuiting key upon the same principle has also been constructed for Mr. Pell, by Messrs. Johnson and Phillips; the spring in this case is, however, somewhat stronger, to prevent unintentional locking when the key is tapped by the finger for observing the range of the deflection on the galvanometer scale. Another advantage possessed by this latter key, and one that is by no means without its value, is that of size. The old pattern key it will be admitted is absurdly small, and its general unhandiness, even for purposes of ordinary testing, is notorious. All sorts of dodges have to be resorted to if more than four wires are required to be connected to it, and any transposition of even these wires, if it be necessary, is always productive of some degree of difficulty and vexation.

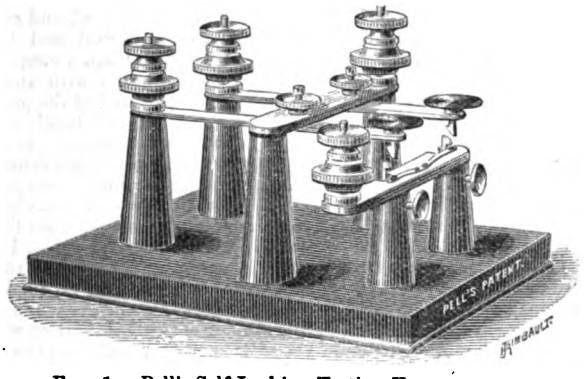

FIG. 1.—Pell's Self-Locking Testing Key.

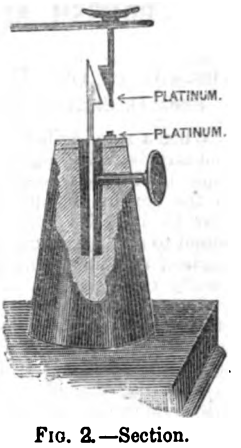

FIG. 2.—Section.

SIXPENNY TELEGRAMS.

The following are the official regulations relating to nland telegrams, to come into force on the 1st proximo. Our readers will, however, notice that the substance of these regulations was given in our issue of the 4th inst.:—

1. Every word, including the addresses, is to be charged for. As a rule, the only address which will be signalled will be that of the recipient, and this will come at the head of the message, the sender's name and address, if to be telegraphed, being signalled after the text. 2. The instructions "By Post" or "By Train," forming as they do part of the address, are to be charged for. 3. The words "Reply Paid" will still not be charged for. When twelve words of reply are paid for, "Reply Paid" is to be signalled in the instructions; when more than twelve words are paid for, "Reply Paid —— words" is to be signalled. In order to diminish the chances of Reply Paid instructions being overlooked, a new prefix has been adopted, viz., SRP and XRP, which is to be used in all cases in which replies have been prepaid. 4. The names of all towns and villages are to be counted as one word each. But the old rule will still apply as regards places in towns like Park Lane, Charing Cross, &c., which are to be counted as two words each. 5. Names of persons, like O'Neil, De la Rue, &c., are to be counted as one word each; but double names like "Smith-Payne" are to be counted as two words. 6. Initial letters are to be counted as formerly, with the exception that the London District initials are to be counted as one word for each set of initials. Thus "S.W." is to be counted as one word. 7. Figures are to be counted, as in Continental telegrams, at the rate of five to a word. Thus "38563" will be one word; "12:35" will be one word; and "2/7/6" will be one word. 8. Mixed figures and letters are to be counted in the manner shown by the following examples:—

104a = two words. | 42nd = two words | 7s. 6d. = four words.

9. a.m. and p.m. when written thus: "am" and "pm," are to be counted as one word each. In fact, any group of letters not exceeding five is, as heretofore, to be counted as one word. 10. The charge for re-direction will be 6d. for every telegram re-directed within the same town, and the full rate for every telegram re-directed from one town to another. Each London District is to be

* Abstract of paper read at the Aberdeen Meeting of the British Association.

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regarded as a separate town. 11. The words "Re-directed from ——" are no longer to be written at the end of the address on the C form, but after the name of the office at which the telegram was originally handed in. The C form of a telegram handed in at Liverpool and re-directed from Birmingham to Cheltenham at 3:20 will read thus :—

Handed in at the } *Liverpool Office and re-directed from Birmingham Office* at 3:20 p.m. Received here at } ——m.

12. Multiple address telegrams are to be charged for in the following manner :—First the total number of words in the addresses and in the text are to be counted and charged for, then 2d. a copy is to be charged for each telegram entitled to be delivered at the reduced rate, and then the text is to be charged for of any telegram (other than the original telegram) not entitled to be delivered at the reduced rate. Handbills explaining this more fully will be sent to every telegraph office, with the book of instructions. 13. The amended address fee is to be 6d. where it formerly was 1s.

BRITISH ASSOCIATION MEETING, 1885.

ADDRESS TO THE MATHEMATICAL AND PHYSICAL SECTION, BY PROF. G. CHRYSTAL, M.A., F.R.S.E., PRESIDENT OF THE SECTION.

When a man finds himself unexpectedly in some unusual situation his first impulse is to look round and see how others have done in like circumstances. I have accordingly run through the addresses of my predecessors in the honourable office of president of Section A, which is fated this year to be filled somewhat unworthily. This examination has, I am bound to say, comforted me not a little. I have found precedents for all kinds of addresses, long and short, even apparently for none at all. The variety of subjects is also suggestive of great latitude. I have found reviews of the progress of mathematical and physical science, discussions of special scientific subjects, dissertations on the promotion of scientific research, and on the teaching and diffusion of science, all chosen in their turn for the subjects of this opening address.

Following some of the most eminent of my forerunners, I propose to be brief ; following the last of them, Prof. Henrici, I shall take for my subject, so far as I have one, the Diffusion of Scientific Knowledge. Apart from the fact that Prof. Henrici's address greatly interested me, and that I find many of his conclusions in agreement with the results of my own experience, and that, therefore, I wish to second him with all my power, I have other reasons for this choice. For more than half the year I am employed with absolute continuity in teaching mathematics, and it has happened for the last eight years or so that the other half has been mainly occupied in a variety of ways with science teaching generally. This is the thing concerning which I have had most experience, and I hold it to be the most respectful course towards my audience to speak to them on the subject that I know best.

Ever since I began to study science I have been deeply interested in the question of how it could best be taught. I believe my meditations in that direction were awakened by some unsuccessful boyish efforts to apply to the satisfaction of a ploughman, who was my friend and confidant, certain principles of natural philosophy to explain the action of his plough. Wisely and unwisely I have always been ardent about the improvement of scientific teaching. I was so long before I dreamt that I should one day be called upon to put my ideas through the cold ordeal of practice. It would not be becoming that I should speak at any time, more particularly to-day, regarding the success of my own efforts, or even regarding my alternate fits of hopefulness and despair. It is enough to say that, in such a cause,

> "Tis better to have loved and lost,
> Than never to have loved at all."

The British Association, by its title, exists for the advancement of science. Now, I hold that one of the essential conditions for that advancement is the existence of a scientific public—a public, like the Athenians of old, eager to hear and tell of some new truth ; eager to discuss and eager to criticise ; ready to appreciate what is novel ; to receive it if sound, to reject it if unsound. It is to such a public that the British Association appeals, and certainly in the past it has not found its public wanting in generosity. What I should wish to see is less of mere friendly onlooking and more participation in the dance.

I am not speaking now merely of a professional public, such as is so prominent in Germany, for instance, made up of teachers and others professionally concerned with science. I refer mainly to that amateur but truly expert public which has always been so honourable a feature of English science, as examples of which I may mention Boyle and Cavendish in former days, and Joule and Spottiswoode in our own. It is quite true that much of that scientific public came in days of yore from the leisured class, whose ratio to the rest of the nation will not improbably decrease in the course of our social development. I think, however, that the loss we may thus sustain will be more than compensated by the continual increase of those who have received higher education of some kind or other, and whose daily occupations give them an interest, direct or indirect, in one or more branches of science.

It may not be amiss to insist for a little on the advantages to science of a great body of men unofficially engaged in scientific research, in writing regarding science, or even in merely turning scientific matter over in their minds. It will not have escaped the notice of those among you who have studied the history of science, that few scientific ideas spring up suddenly without previous trace or history. It is perfectly true that in many cases some mind of unwonted breadth and firmness is required to formulate the new doctrine, and carry it to manifold fruition ; but a close examination always shows that the sprite was in the air before the Prospero came to catch him. It is very striking to notice, in the history of algebra for instance, long periods in which great improvements were effected in the science, which cannot be traced to any individual, but seem to have been due merely to the working of the minds of scientific men generally upon the matter, one giving it this little turn, another that, in the main always for the better. Like every other thing that has the virtue of truth in it, science grows as it goes, not like the idle gossipping tale by the casual accretion of heterogeneous matter, but by the chemical combination of pure element with pure element in reasonable proportion.

I know of no greater advantage for science than the existence of an army of independent workers sufficiently enlightened for self-criticism, who shall test the results and theories of their day. Great and indispensable as are the uses of professional schools of scientific workmen, they are open to one great and insidious danger. The temptation there to swear by the word of the master is often irresistible. Not to speak of its being often the readiest avenue to fame and profit, it is the perfectly natural consequence of the contact of smaller mind with greater.

There are few things where the want of an enlightened scientific public strikes an expert more than in the matter of scientific text-books. If the British public were educated as it ought to be, publishers would not be able to palm off upon them in this guise the ill-paid work of fifth-rate workmen so often as they do ; nor would the scientific articles and reviews in popular journals and magazines so often be written by men so palpably ignorant of their subject.

We all have a great respect for the integrity of our British legislators, whatever doubts may haunt us occasionally as to their capacity in practical affairs. The ignorance of many of them regarding some of the most elementary facts that bear on everyday life is very surprising. Scientifically speaking, uneducated themselves, they seem to think that they will catch the echo of a fact or the solution of an arithmetical problem by putting their ears to the sounding-shell of uneducated public opinion. When I observe the process which many such people employ for arriving at what they consider truth, I often think of a story I once heard of an eccentric German student of chemistry. This gentleman was ill, but, like all his nation, systematic. When he had a precipitate to weigh, instead of resorting to his balance, he would go the round of the laboratory, hold up the test-tube before each of his fellow-students in turn, and ask him to guess the weight. He then set down all the replies, took the average, and entered the result in his analysis.

I will not take up your time in insisting upon the necessity of the diffusion of science among that large portion of the public who are, or ought to be, appliers of scientific knowledge to practical life. That part of my theme is so obvious, and has been of late so much dwelt upon, that I may pass it by and draw your attention to another place in which the shoe pinches. All of you who have taken any practical interest in the organisation of our educational institutions must be aware of the great difficulty in securing the services of non-professional men of sufficent scientific knowledge to act on School Boards, and undertake the direction of our higher schools. It is no secret among those who carefully watch the course of the times in these matters that our present organisation is utterly insufficient ; that it has not solved, and shows every day less likelihood of solving, the problems of higher education. This arises, to a great extent, from the fact that a scientifically educated public of the extent presupposed by that organisation really does not at present exist.

If the existence of a great scientific public be as important as I think I have shown it to be, it must be worth while to devote a few moments to the consideration of the means we adopt to produce it both in the rising and in the risen generation.

It would naturally be expected that we should look carefully to the scientific education of our youth, to see that the best men and the best means that could be had were devoted to it ; that we should endeavour to make for them a broad straight road to the newest and best of our scientific ideas ; that we should exercise them when young on the best work of the greatest masters ; familiarise them early with the great men and the great feats of science, both of the past and of the present ; that we should avoid retarding their progress by making details and illustrations or particular rules and methods ends in themselves. Granting that it is impossible to bring every learner within reach of the fullest scientific knowledge of his time, it would surely be reasonable to take care that the little way we lead him should not be along some devious by-path, but towards some eminence from which he might at least *see* the promised land. The end of all scientific training of the great public I take to be, to enable each member of it to look reason and nature in the face, and judge for himself what, considering the circumstances of his day, may be known, and not be deceived regarding what must to him remain unknown. If this be so, surely the ideal of scientific education which I have sketched is the right one ; yet it is most certainly not the ideal of our present system of instruction. To attain conviction on that head it is sufficient to examine the text-books and examination papers of the day.

Let us confine ourselves for the present to the most elementary of all the exact sciences, viz., geometry and algebra. These two, although among the oldest, are, as Prof. Cayley very justly reminded the Association not long ago, perhaps the most progressive and promising of all the sciences. Great names of antiquity are associated with them, and in modern times an army of men of genius have aided their advance. Moreover, it cannot be said that this advance concerns the higher parts of these sciences alone. On the contrary, the discoveries of Gauss, Lobatschewsky, and Riemann, and of Poncelet, Möbius, Steiner, Chasles, and Von Stawdt, in geometry, and the labours of De Morgan, Hamilton, and Grassman, not to mention many others, in algebra, have thrown a flood of light on the elements of both these subjects. What traces of all this do we find in our school books ? To be sure *antiquity* is stamped upon our geometry, for we

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use the text-book of Euclid, which is some two thousand years old ; but where can we point to the influence of *modern* progress in our geometrical teaching? For our teaching of algebra, I am afraid, we can claim neither the sanction of antiquity nor the light of modern times. Whether we look at the elementary or at what is called the higher teaching of this subject, the result is unsatisfactory. With respect to the former, my experience justifies the criticism of Prof. Henrici; and I have no doubt that the remedy he suggests would be effectual. In the higher teaching, which interests me most, I have to complain of the utter neglect of the all-important notion of algebraic form. I found, when I first tried to teach University students co-ordinate geometry, that I had to go back and teach them algebra over again. The fundamental idea of an integral function of a certain degree, having a certain form and so many coefficents, was to them as much an unknown quantity as the proverbial x. I found that their notion of higher algebra was the solution of harder and harder equations. The curious thing is that many examination candidates, who show great facility in reducing exceptional equations to quadratics, appear not to have the remotest idea beforehand of the number of solutions to be expected ; and that they will very often produce for you by some fallacious mechanical process a solution which is none at all. In short, the logic of the subject, which, both educationally and scientifically speaking, is the most important part of it, is wholly neglected. The whole training consists in example grinding. What should have been merely the help to attain the end has become the end itself. The result is that algebra, as we teach it, is neither an art nor a science, but an ill-digested farrago of rules, whose object is the solution of examination problems.

The history of this matter of problems, as they are called, illustrates in a singularly instructive way the weak point of our English system of education. They originated, I fancy, in the Cambridge Mathematical Tripos Examination, as a reaction against the abuses of cramming bookwork, and they have spread into almost every branch of science teaching—witness test-tubing in chemistry. At first they may have been a good thing ; at all events, the tradition at Cambridge was strong in my day that he that could work the most problems in three or two and a-half hours was the ablest man, and, be he ever so ignorant of his subject in its width and breadth, he could afford to despise those less gifted with this particular kind of superficial sharpness. But in the end it came all to the same ; we were prepared for problem working in exactly the same way as for bookwork. We were directed to work through old problem papers, and study the style and peculiarities of the day and of the examiner. The day and the examiner had, in truth, much to do with it, and fashion reigned in problems as in everything else. The only difference I could ever see between problems and bookwork was the greater predominance of the inspiriting element of luck in the former. This advantage was more than compensated for by the peculiarly disjointed and, from a truly scientific point of view, worthless nature of the training which was employed to cultivate this species of mental athletics. The result, so far as problems worked in examinations go, is, after all, very miserable, as the reiterated complaints of examiners show ; the effect on the examinee is a well known enervation of mind, an almost incurable superficiality, which might be called Problematic Paralysis—a disease which unfits a man to follow an argument extending beyond the length of a printed octavo page. Another lamentable feature of the matter is that an enormous amount of valuable time is yearly wasted in this country in the production of these scientific trifles. To the occasional working and propounding of problems as an aid to the comprehension of a subject, and to the starting of a new idea, no one objects, and it has always been noted as a praiseworthy feature of English methods ; but the abuse to which it has run is most pernicious.

All men practically engaged in teaching who have learned enough, in spite of the defects of their own early training, to enable them to take a broad view of the matter, are agreed as to the canker which turns everything that is good in our educational practice to evil. It is the absurd prominence of written competitive examinations that works all this mischief. The end of all education nowadays is to fit the pupil to be examined ; the end of every examination not to be an educational instrument, but to be an *examination* which a creditable number of men, however badly taught, shall pass. We reap, but we omit to sow. Consequently our examinations, to be what is called fair—that is, beyond criticism in the newspapers—must contain nothing that is not to be found in the most miserable text-book that any one can cite bearing on the subject. One of my students, for example, who was plucked in his M.A. examination, and justly so if ever man was, by the unanimous verdict of three examiners, wrote me an indignant letter because he believed, or was assured, that the paper set by the examiners could not have been answered out of Todhunter's "Elementary Algebra." I have nothing to say, of course, against that or any other text-book, but who put it into the poor young man's head that the burden lay with me to prove that the examination in question ought to contain nothing but what is to be found in Todhunter's "Elementary Algebra?" The course of this kind of reasoning is plain enough, and is often developed in the newspapers with that charming simplicity which is peculiar to honest people who are at the same time very ignorant and very unthinking. First, it follows that lectures should contain nothing but what is all to be found in every text-book ; secondly, lectures are therefore useless, since it is in the text-book ; thirdly, the examination should allude to nothing that is not in the text-books, because that would be unfair ; fourthly, which is the coach or crammer's deduction, there should be nothing in the text-book that is not likely to be set in the examination. The problem of the writer for a text-book has come now, in fact, to be this—to write a booklet so neatly trimmed and compacted that no coach, on looking through it, can mark a single passage which the candidate for a minimum pass can safely omit. Some of these text-books I have seen, where the scientific matter has been, like the lady's waist in the nursery song, compressed "so gent and sma'," that the thickness of it barely, if at all, surpasses what is devoted to the publisher's advertisements. We shall return, I verily believe, to the Compendium of Martianus Capella. The result of all this is that science, in the hands of specialists, soars higher and higher into the light of day, while educators and the educated are left more and more to wander in primeval darkness.

When our system sets such mean ends before the teacher, and encourages such unworthy conceptions of education, is it to be wondered at that the cry arises that pupils degenerate beneath even the contemptible standards of our examinations? These can hardly be made low enough to suit the popular taste. It is no merit of the system we pursue, but due simply to the better among our teachers, men many of them who work for little reward and less praise, that we have not come to a worse pass already. Some even of the much-abused crammers have conceptions of a teacher's duty far higher than the system-mongers of the day, whom it is their special business to outwit ; and it is but fair to allow to such of these also as deserve it part of the credit of stemming the torrent of degeneration. We place our masters in positions such that that their very bread depends upon their doing what many of them know and will acknowledge to be *wrong*. Their excuse is, "We do so and so because of the examination."

The cure for all this evil is simply to give effect to a higher ideal of education in general, and of scientific education in particular. Science cannot live among the people, and scientific education cannot be more than a wordy rehearsal of dead text books, unless we have living contact with the working minds of living men. It takes the hand of God to make a great mind, but contact with a great mind will make a little mind greater. The most valuable instruction in any art or science is to sit at the feet of a master, and the next best to have contact with another who has himself been so instructed. No agency that I have ever seen at work can compare for efficiency with an intelligent teacher, who has thoroughly made his subject his own. It is by providing such, and not by sowing the dragon's teeth of examinations, that we can hope to raise up an intelligent generation of scientifically educated men, who shall help our race to keep its place in the struggle of nations. In the future we must look more to men and to ideas, and trust less to mere systems. Systems have had their trial. In particular, systems of examination have been tested and found wanting in nearly every civilised country on the face of the earth. Backward as we are here, we are stirring. The University of London, after rendering a great service to the country by forcing the older universities to give up the absurd practice of restricting their advantages to persons professing a particular shade of religious belief, has for many years pursued its career as a mere examining body. It has done so with rare advantages in the way of Government aid, efficient organisation, and an unsurpassed staff of examiners. Yet it has been a failure as an instrument for promoting the higher education—foredoomed to be so, because, as I have said, you must sow before you can reap. At the present time, with great wisdom, the managers of that institution have set about the task of really fitting it out for the great end that it professes to pursue. If they succeed in so doing they will confer upon the higher education one of the greatest benefits it has yet received. They have an opportunity before them of dethroning the iron tyrant Examination which is truly enviable. This movement is only one of the signs of the times. Among the younger generation I find few or none that have any belief in the "learn when you can and we will examine you" theory ; and small wonder, for they have tasted the bitterness of its fruit. *Laissez faire* as a method in the higher education no longer holds its place, except in the minds of inexperienced elderly people, who cling, not unnaturally, to the views and fashions which were young when they were so.

All the same, the task of reformation is not an easy one. Examinations have a strong hold upon us, for various reasons, some good, some bad, but all powerful. In the first place, they came in as an outlet from the system of patronage, which, with many obvious advantages, some of which are now sorely missed, had become unsuited to our social conditions. There is a certain advantage in examinations from the organiser's point of view, which any one who, like myself, has to deal with large quantities of pretty raw materials will readily understand. Again, there is an ordinary bustle about the system that pleases the business-loving eye of the Briton. Yearly the printed sheets go forth in every corner of the land. The candidates meet and, in the solemn silence of the examination hall, the inspector, the local magnate, or the professor, sits, while for two or three busy hours the pens go scratching over the paper. A feeling of thankfulness comes over the important actor in this well-ordered scene, that the younger generation have such advantages that their fathers never knew. It is only when the answers are dissected in the examiner's study that the rottenness is revealed underlying the fair outward skin. But then the examiner must go by his standards ; he must consider what is done elsewhere, and what is to to be reasonably expected. Accordingly he takes his report and quickly writes so many per cent. passed. Then the chorus of reporting examiners lift up their voices in wonderful concordance ; and all, perhaps even the examiners, are comforted. There is something attractive about the whole thing that I can only compare to the pleasure with which one listens to the hum of a busy factory or to the roaring of the forge and ringing of the anvil. But what avails the hum of the factory if the product be shoddy, and what the roar of the forge and the ring of the anvil if the metal we work be base?

In conclusion, let us consider for a moment what might be done for the risen generation, who are too old to go formally to school, and yet not too old to learn. In their education such bodies as the British Association might be very helpful. Indeed, in the past, the British Association has been very helpful in many ways. It can point to an admirable series of reports on the progress of science, for which everyone who, like myself, has used them, is very grateful. It is much to be desired that these reports should be continued, and extended to many branches of science which they have not yet covered.

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The Association has at present, I believe, a committee of inquiry into science-teaching generally. This is typical of a kind of activity which the Association might very profitably extend. This Association, with its long list of members bristling with the names of experts in every science, not drawn from any clique or particular centre, but indiscriminately from the whole land, might take upon itself to look into the question of scientific text books and treatises. Even if it did not set up a censorship of the scientific press, which might be an experiment of doubtful wisdom, although some kind of interference seems really wanted now and then, it might set itself to the highly useful work of filling the gaps in our scientific literature. There is nothing from which the English student suffers so much as the want of good scientific manuals. The fact is that the expense of getting up such books in the country is so great, and the demand for them, though steady, yet so limited, that it will not pay publishers to issue them, let alone remunerate authors to write them. In my student days the scarcity was even greater than it is now, and in fact then no one could hope to get even a reasonable acquaintance with the higher branches of exact science unless he had some familiarity with French or German at the very least—a familiarity which was rare among my fellow students either in England or in Scotland. Might not the British Association now and then request some one fitted for the task to write a treatise on such and such a subject, and offer him reasonable remuneration for the time, labour, and skill required?

Another field in which the Association might profitably extend its labours appears to me to be the furnishing of reports, from time to time, on the teaching of science in other countries, and the drawing up of programmes of instruction for the guidance of schoolmasters and of those who are reading for their own instruction. There is no need to impose these programmes on any one. I would leave as much freedom to the teacher as I would to the private student. The programme drawn up by the Society for the Improvement of Geometrical Teaching, for example, has been very useful to me as a teacher, although I do not follow it or any other system exclusively. The great thing is not to fall asleep over any programme or system. For the matter of that, Euclid would do very well, in the earlier stages of school instruction at least, provided he were modernised, and judiciously discarded at that part of the student's career where a lighter vehicle and more rapid progress become necessary. In such programmes as I contemplate the bearing of recent discovery on the elements of the various sciences could be pointed out, and the general public kept in this way from that gross ignorance into which they are at present allowed to fall.

The British Association has of late, I believe, given its attention to the encouragement of local scientific activity. There can be no doubt that much could be done in this way that is not done at present. The concentration of scientific activity in metropolitan centres is beginning to have a depressing effect in Great Britain. This is seen in the singularly unequal way in which Government aid is distributed over the country. Large sums are spent—sometimes we outsiders think not to the best purpose—through certain channels, simply because these channels happen to have a convenient opening in some Government office in London, or in some place in that important city which has easy access to the ruling powers; while applications on behalf of other objects not less worthy are met with a refusal which is sometimes barely courteous. The result is that local effort languishes, and men of energy, finding that nothing can be done apart from certain centres, naturally gravitate thither, leaving provincial desolation to become more desolate.

I think that our great scientific societies—the Royal Societies of London and Edinburgh and the Royal Irish Academy—might do more than they do at present to prevent this languishing of local science, which is so prejudicial to the growth of a scientific public. Besides their all-important publishing function, these bodies have for a considerable time back been constituted into a species of examining and degree-conferring bodies for grown-up men. That is to say, their membership has been conferred upon a principle of *exclusion*. Instead of any one being *admitted* who is willing to do his best, by paying his subscription or otherwise, to advance science, every one is *excluded* who does not come up to the standard of a certain examining body. Now, against this proceeding by itself I have nothing to say, except that it appears to belong to the pupillary age both of men and nations. It is not the honouring of the select few that I think evil, but the exclusion of the unhonoured many. The original intention in founding these societies was to promote the advancement of science. How that is done by excluding any one, be it the least gifted among us, who is honestly willing to contribute his mite towards the great end, fairly passes my comprehension. If it is thought necessary, for the proper cultivation of the scientific spirit among us, that the degree-conferring function should be continued, let there by all means be an inner court of the temple, a place for titular immortals; but let there be also a court of the Gentiles, where those whose fate or whose choice it is to serve science unadorned may find a modest reception. I believe that the adoption of this suggestion would enormously extend the usefulness of our great scientific societies, and give to their voice a weight which it never had before. At all events, if the trammels of tradition, or some better reason with which I am unacquainted, should prevent them from broadening their basis in the way I indicate, nothing prevents the British Association, with its more liberal constitution, from considering what may be done for the scientific plebeian.

There is one other function of the British Association in connection with which I wish to venture another suggestion. During the annual meeting, scientific men have an opportunity of making each other's acquaintance. Great men exchange ideas with great men; and, most important of all, young and little men have a chance, rarely otherwise afforded, of taking a nearer view of the great. What I would suggest for consideration is, whether it might not be possible to form an organisation which would in a certain sense carry this advantage through the whole year. I have already alluded more than once to the difficulties that the scientific public—and here I include professional men generally, in fact all but the leaders of science—have in keeping pace with recent advances. Would it not be possible to have an arrangement enabling at least every large centre of the higher education to have periodically the benefit of communion with and instruction from the high priests of the various branches of science? How glad we, the teachers of science in Edinburgh for example, would be to have a course of lectures once every three or four years from Professors Cayley, Sylvester, Stokes, Adams, Lord Rayleigh. In this way effect would be given to the principle which cannot be too much insisted upon, that the power of the spoken word far exceeds that of the written letter. Not only should we learn from the mouths of the prophets themselves the highest truths of science, but the present generation would thus come to know face to face, as living men, those whose work will be the glory of their time and a light for future ages. From the want of a proper circulating medium the influence of great scientific men very often does not develop until they and the secrets of their insight have gone from among us. The object of what I propose is to make these men more of a living power in their own lifetime.

THE ELECTRIC LIGHT AND ATMOSPHERIC ABSORPTION.*

The absorption of light by the earth's atmosphere is a subject of very great importance, for it affects and modifies our views of everything around us. We recognise its importance to ourselves when we reflect that seeing is our only means of direct communication with bodies at a distance. The sense of smell carries us a little way out of ourselves, and the sense of hearing carries us a little farther, the one through fine particles carried by the atmosphere, and the other by its regular vibrations; yet the direct effects of these are manifest only in the immediate neighbourhood in which they are produced, and it is only by means of some agency—such as electricity or some other mode of motion—that sounds can be transferred into some other form of energy and retransferred so as to reproduce themselves as signals at considerable distances. The sense of sight reveals not only the outline and colour of bodies immediately around us, but that very absorption by the atmosphere of which, as our president has told us, we know so little, and of which I have to speak. It enables us to judge of distance and lends the charm of tone and colour to the landscape; it warns us of the gathering cloud, and in the twilight of the morning it tells us of the coming sunshine. Light reveals to us not only things within our atmosphere, but Prof. Stokes, in his course of lectures here, has shown the various ways in which it may be employed to investigate the condition and composition of the sun and stars, and to resolve the nebulæ. Within the last ten days it has revealed to us that in the centre of a nebulous mass of matter there is said to be a concentration of the luminous gases into a central mass, as though a new sun were just caught in the act of its formation. Yet, we must remember that we have now only received the record of an event which happened many thousands of years ago, and that the waves which have brought it to us, travelling at the rate of 192,000 miles a second, have been on their journey for that long period of years. Since the days of Newton we have learned to regard the sun's light as composite in character. With a wedge or prism of glass he showed that it consists of different kinds of radiations, which are bent or refracted in different degrees on passing through the prism, and that the result is a spectrum of different colours—red, orange, yellow, green, blue, and violet, where each degree of bending is accompanied by a special shade or colour, and the sum of all combined makes up the total sunlight. The sun's heat has been studied independently, and has also been found to consist of radiations, or we may call them rays, which are bent in different degrees on passing through a prism. The same is true of the actinic power or chemical action of the sun, each degree of bending corresponding to a definite amount of chemical or photographic power. Not only so, but corresponding to a given degree of bending by the prism, or rather corresponding to a given wave-length, the heat, the light, and the actinic power from the same source are always present in the same proportions. The same is true of the spectrum of the electric light from glowing carbon poles, or of the radiations from a glowing gas. Take, for instance, the green band of thallium. The burning of this substance at the temperature of the electric arc causes it to give out its own special radiation in the green, which possesses a certain amount of heating, light-giving, and actinic powers, and these are so related that whatever alters the amount of the one alters each of the others in the same proportion. If, for instance, the vapour of thallium at a lower temperature absorbs one-fourth of the light, it also absorbs one-fourth of the heat and one-fourth of the actinic power of this green ray. This statement is not inconsistent with the fact that there are rays of obscure heat which give no light, and rays which are chemically active which give no light and very little heat, but will embrace these cases, only the proportion of light in them is nothing. Take again the rays of different wave length, such as we may regard radiant heat, light, and actinic power as only different results, or as different forms of the energy of the self-same radiation. Let us examine the spectrum of selenium. In each of these rays, then, the heating power, the light-giving and actinic power are each present there, in a definite and always in the same relation to one another, but not in the same proportions for the different *bands* (colours). Any substance which absorbs a ray of definite wave length will have absorbed its heating, its light-giving, and its actinic powers in the same proportions, although we may not be able to detect the presence of them. And here comes our

* Evening lecture delivered before the British Association, at Aberdeen, on Friday, Sept. 11, 1885.

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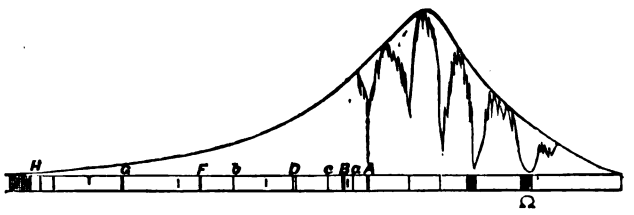
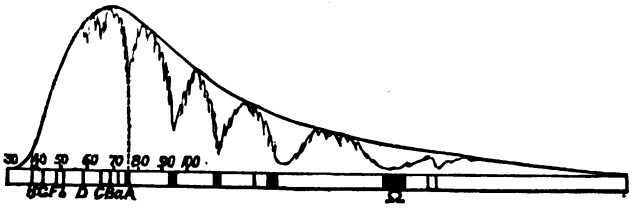
difficulty, the difficulty of measuring and comparing these effects, which are not absolute but relative, and which are always being dissipated, so diminishing our stock of useful energy. To get over this difficulty of the measurement of the energy of radiations, one takes his photographic camera, and, devoting himself to *fastening on* a special portion of the spectrum, he maps its energy by means of its action on certain prepared chemicals. In this field there are many workers at the violet and ultra-violet rays, which produce strong chemical action on salts of silver, but for the red and beyond the red end of the spectrum the progress made is especially due to Captain Abney, who has greatly extended our knowledge in this direction, and opened up and made accurate chemical measurements in parts of the spectrum which were before unknown, to which the door had only just been thrust a little open by Herschel and other investigators, who detected differences of chemical action in different parts of the red end of the spectrum. Another observer takes Melloni's thermo-electric pile, which measures the energy of radiations by the change of temperature produced by them at the junctions of two metals, antimony and bismuth, the change of temperature being measured by the thermo-electric current so produced. [Experiment with thermopile and galvanometer.] Now, to get nearer and nearer to the single radiations the breadth of the thermopile must be more and more reduced, and with it the electric current which deflects the needle of the galvanometer. With this instrument the general distribution of heat throughout the spectrum and beyond the red end have been measured. But even the line thermopile has considerable breadth, and so Prof. Langley invents his bolometer, wherein by the change of temperature of a wire of platinum from $\frac{1}{1000}$ to $\frac{1}{10000}$ of an inch in thickness, *i.e.*, so fine that it almost requires a microscope to see it, he measures the heating effect of solar and other radiations. With this instrument, which is far more sensitive than any linear thermopile, Prof. Langley has investigated the energy of the radiations throughout the solar spectrum. He has shown us that, although Capt. Abney had extended the spectrum nearly twice the length of the visible spectrum beyond the red, and had made far more accurate measurements in this region than any which had been made before, yet he had not told us half the tale, for Prof. Langley's investigations show that the portion beyond the red is six times as long as the visible spectrum. Let me explain what I mean when I speak of the length of the spectrum. With prisms we obtain spectra of different lengths and unequal spreading of the colours, *i.e.*, unequal bending of waves of the same length, according as we change the material of our prisms. Hence, in measuring the heat or the chemical action in a length of, say, 1 mm. of the spectrum, we get one value with a glass prism, another with quartz, another with rock-salt, and another with bisulphide of carbon in the same region of the spectrum, and with the same general bending of the waves we shall have a different amount of spreading out or dispersion of the waves of different lengths, and an unequal lengthening of the spectrum in its various parts. Not only so, but the long waves are compressed together, and the short waves are spread out, so that as regards wave-length our estimate of the heating and the energy of 1 mm. in the red, and beyond the red, is far too high, because the waves are there too much compressed. In the spectrum of the sun and of the electric arc the greatest heating in a length of 1 mm. of the spectrum formed by a prism is beyond the red; but if we arrange the distribution of the colours



Prismatic Spectrum.



Normal or Diffraction Spectrum.

of our spectrum according to wave-lengths, the greatest heating effect, or the maximum energy, lies in the yellow, *i.e.*, the part which gives the brightest light. We may get more exact ideas by comparing diagrams in which the length of the spectrum is represented as a horizontal line, and the intensity at any point of it is represented by a height drawn upwards from that point. The bounding line through all the upper ends will then enclose an area which will represent the [distribution of] energy throughout the spectrum. The prismatic spectrum is apt to give us wrong ideas, from the crowding together of the red end of the spectrum. Reckoning wave lengths in 10,000ths of a mm., the ultra-violet extends from about 4 to about 2½/10,000ths of 1 mm., the visible spectrum extends from 4 to about 7·6/10,000ths, and in the infra-red Captain Abney has measured to a wave-length of 12, and Prof. Langley has measured or shown the existence of waves whose lengths extend beyond 24/10,000ths of 1 mm., *i.e.*, nearly 1/10,000th of an inch. With the visible part, from wave-length 4 to 7·6/10,000ths, in which part also lies the region of maximum energy, we are principally concerned this evening. We have as yet no established photometric method for the absolute measure of visible radiations, but there is great promise that we are not far from as delicate a test for light as Prof. Langley's bolometer is for radiant heat. This delicate test depends upon the very remarkable sensitiveness to light which is possessed by the substance selenium. Specially prepared selenium has less electrical resistance on exposure to light than it has when kept in the dark, so that placing it in the dark and joining it up in an electric circuit with a battery and galvanometer there will be a greater current, causing a deflection of the galvanometer needle when the selenium is exposed to light. All the visible rays of the spectrum change the electrical condition of selenium, but the greatest change is produced by the greenish yellow waves, *i.e.*, the brightest part of the spectrum. The obscure heat rays produce comparatively little change, and the ultra-violet rays do not seem to have the power of producing any E.M.F. in the selenium; hence selenium gives a very delicate mode of measuring the illuminating power, or the energy of the visible radiations by the increase in the electric current as shown by the deflection of the galvanometer. Last year I received from Mr. Fritts, of New York, some selenium cells which were far more sensitive to light than any which had been previously made. Here is one (No. 23) whose resistance of 14,000 ohms in the dark was changed to 170 ohms in bright sunlight. Another (No. 129) had a resistance of 200,000 ohms in the dark, which was reduced to 940 ohms, *i.e.*, less than $\frac{1}{100}$th part of the original resistance by exposure to sunlight. I have found that exposure to one candle at a distance of one foot reduces the resistance of each of these to one half its previous value. Another cell had its electrical resistance reduced from 75,000 ohms to 43,000 ohms by the same exposure. In this change of 32,000 ohms for an illumination of one candle we see that we have a means of measuring very small differences of illuminating power, and therefore a means specially adapted to measure small differences due to absorption of light by the earth's atmosphere. Many will have seen the selenium eye made by Sir William Siemens to illustrate this action of light. A series of observations taken throughout the day with the *gold leaf face* of the selenium cell exposed to the south-eastern portion of a cloudless sky showed a gradual increase of current from 9:30 to 11:30 in the morning, a maximum steady current lasting until about 1:30, followed by a gradual diminution of current from 1:30 until 4 o'clock.

Hour	9:37	10:5	10:30	11:0	11:35	12:0	12:30
Deflections..	190	196	209	223	250	250	244

Hour	1:0	1:30	2:0	2:30	3:0	3:30	4:0
Deflections..	245	249	228	188	173	172	108

It will be seen that this substance—in which the energy of radiations in the visible spectrum seems to be directly converted into electrical energy—gives promise of a means of determining the energy of the simple radiations from the run or the electric light or any other source, and also of determining the amount of absorption by solid liquid or gaseous transparent media. When a beam of white light falls upon a coloured substance, such as gold leaf, a portion of each kind of light is regularly reflected, giving a reflected beam of white light; another portion of the light enters a little way into the substance, and after being reflected from molecule to molecule is thrown back again and scattered in all directions. This light reveals the presence and colour of the substance. The remainder of the light enters and penetrates deeper and deeper into the substance and becomes absorbed in it, the energy of these radiations being converted into energy of motion of the molecules of the body, or a portion may pass through. In that case its colour will be complementary to the colour of the light thrown back, or scattered by reflection in the case of thin gold leaf. The colour transmitted will be green. On looking down into a mountain stream after a heavy storm, when it contains fine particles of matter floating in it, the light reflected from the bottom is of a deep brown colour; so transparent is it that but little light is scattered except from its surface, but blue light is absorbed in greater abundance than the other colours. If a very little milk be added to a glass of water, the light passing through the mixture becomes browner than before, but the light scattered by reflection will be blue. At the same time a great quantity of white light is scattered, and the mixture is rendered less transparent; hence if two glasses—one of water from the mountain stream, and the other of milk and water—are placed side by side on a white cloth and looked at from above, the water from its transparency will appear brown, the source of light being the white cloth, but the milk and water will appear blue. The milk and water is so opague that it is mostly, or it may be entirely, seen by light which has been scattered by the particles, and in this light the blue is most abundant. Any mixture which is partly transparent and has very fine particles suspended in it will produce similar effects. Thus resin dissolved in alcohol and mixed with water gives a bluish tinge seen by reflected light, and imparts a yellowish-red or even red tinge to light which has been transmitted through it. Opalescent glass has the same property. The explanation of these facts is at once seen by examining the spectrum of light which has been reflected from the liquid. Those of us who come from the neighbourhood of London or from large manufacturing towns have abundant opportunity of studying the effect produced when sunlight is transmitted through various thicknesses of smoke full of very fine particles which have not been fully consumed. [Experiment with didynium]. When light from the glowing carbon poles of the electric arc falls upon a medium whose molecules have a great tendency to vibrate at certain definite rates, the vibrations of the ether will be absorbed in exciting sympathetic vibrations on the molecules of the medium, just as the energy of vibration of the air excited by the voice sustaining a sound of given pitch may be spent in producing sympathetic vibrations of the same wave-length in a string or organ pipe. A series of

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slight knocks, if given in proper time, will set a pendulum in oscillation. The very slightest taps at the rate of 1 a second will cause ever-increasing swings in a seconds pendulum ; so when the natural time of vibration of the molecules of a body harmonises with waves of light of a certain length these waves falling upon those molecules will set them in vibration, and the energy of the wave motion will be spent in setting the molecules of the body in motion. The waves of the same period of vibration of the molecules of the body will be internally absorbed, and the light of this special wave-length will be stopped. The experiment of Bunsen and Kirchhoff with sodium vapour in front of the slit of a spectroscope shows what takes place. If the source of light behind the slit is of lower temperature than the sodium flame, the sodium flame will increase the brightness of the sodium band ; but if the source of light behind the slit is of higher temperature than the sodium flame, some of the vibrations will be stopped, and if there be sufficient difference of temperature in the two flames black bands will take the place of the bright sodium bands, and we at once have the explanation given by Bunsen and Kirchhoff of the dark lines of sodium and other substances in the spectrum of the sun. [Try the same experiment with the vapour of selenium.] The presence of the vapour of sodium and other substances in the upper regions of the sun's atmosphere causes the absorption of the bands peculiar to those substances, and the light from the lower regions of the solar atmosphere is deprived of those bands in passing through, and so comes to us with dark lines in the position of those bands. When the molecules can vibrate at different rates, the dark lines are sometimes grouped in one part of the spectrum, and weaken light of one colour more than of another, as for instance, with vapour of iodine ; in the liquid state the molecules are too close to allow of their free motion, their vibrations are disturbed, and the absorption bands widen out as the thickness of the medium is increased. The characteristic bands of substances and their changes may be studied in dilute solutions of liquids and in coloured glasses. But I will not dwell on this part of the subject, seeing that a few months ago it was so ably treated and explained by Prof. Stokes in his Burnet lectures, which are now within the reach of all. Not only glowing vapours, but gases at ordinary temperatures produce black lines in a continuous spectrum. We may see the lines of absorption by nitrogen and oxygen in the atmosphere by sending a beam of light through nitrous oxide fumes, giving many telluric black lines, which are mostly towards the less refrangible end of the spectrum. Besides these, there are many other gases and vapours in our atmosphere, and especially the vapour of water, each absorbing light of special wave lengths, and adding to the dark telluric rays ; but these vary greatly with the quantity of water vapour in the atmosphere, and with the length of path through the atmosphere traversed by the beam. The group D, known as the sodium band, is formed partly of metallic lines and partly rays of absorption, due to the vapour of water. These atmospheric lines, known as the rain bands, which have been carefully mapped by M. Cornu, vary in their appearance from day to day, and from hour to hour, according to the state of moisture of the air and the height of the sun above the horizon. The coefficient of absorption for any given ray may be found by measuring its intensity in the solar spectrum at different times of the day, so that the light travels a different length of path through the earth's atmosphere. Photographs of the solar spectrum, taken at different times of the day, show the growth of the telluric lines, or, with Prof. Langley, we may climb a mountain, and look down on the red dust and take observations of the spectrum and of the deep blue colour of the sky, getting deeper and deeper, almost to blackness, as we ascend, whilst some one else is observing down below with the extra thickness of half the earth's atmosphere between the two observers. The changes in the telluric rays due to water vapour are sometimes very rapid, as in M. Cornu's observations on a winter's day, when the air was very dry and cold, where the telluric rays were very intense at sunrise, but in less than an hour they were scarcely visible, and only the metallic lines remained. The breadth of the telluric rays and the energy consequently lost by their absoption depend upon the height of the sun above the horizon, and M. Cornu proposes to measure the absorbing power of the atmosphere and the amount of water vapour in it by comparing the telluric lines with the metallic lines near them for equality of blackening. We must distinguish between this purely selective aborption of separate rays, whereby dark lines are produced in definite positions in the spectrum, and a general absorption by the atmosphere, which has been shown to depend greatly on the presence of particles of matter or dust in it. Larger particles reflect and scatter a beam of light, and treat light of all kinds or colours nearly in the same way. This happens when the size of the particles is large compared with a wave-length of any kind of light. By these a beam of white light is said to be partially absorbed, but the sifting out of rays has been the same for the different kinds of light, and the remainder which passes through is still white light. The smaller particles of dust or mist begin to absorb selectively, being small enough to be affected differently by, and therefore to affect differently, the long and short waves of ether. In this case the short waves, or blue end of the spectrum, are absorbed more readily than the long waves of the red end of the spectrum, and in the beam which passes through the blue is wanting. As the particles are smaller and smaller we have less and less of absorption, even of the blue end of the spectrum, until the molecule or atom asserts itself by picking out those vibrations of the ether which harmonise with its own special rates of vibration, and leaves the transmitted beam with dark lines in the position of its special black absorption lines. These may by the analogy of sound be said to be the special tones of the gas or vapour, and may be distributed throughout the spectrum. Thus, for every different small portion of the spectrum there are different values of the coefficient of absorption by the earth's atmosphere in consequence of the selective absorption of the various parts, and, as Prof. Langley has shown, it will be necessary to measure these special coefficients of absorption in order to find the true nature of the solar light and heat. Investigations, many of them by Pouillet and others, made before the discovery of the cause of the dark lines of Frannhofer have given the amount of the general absorption of light from the sun or stars in passing through the earth's atmosphere as about 20 per cent. of the whole. Prof. Langley has shown that the effect of the absorption being selective instead of being the same for all the rays must necessarily be an increase in this percentage, which he is disposed to estimate at 40 per cent. rather than at 20 per cent. His investigations also lead him to the conclusion that the coefficient of absorption increases from the red end all the way along the spectrum, so that outside the earth's atmosphere the sun would have a strongly bluish tint, and that the maximum of solar energy would be in the green instead of the orange-yellow. The absorption by the earth's atmosphere may be studied by means of artificial lights on the surface of the earth. In mapping the spectra M. Jansen lit a bonfire, and observed the atmospheric lines from a point 13 miles away, and MM. Egoroff and Thollon have determined the order of disappearance of some of the more prominent absorption lines for different thicknesses of air between Mont Valerien and the Observatory at Paris. But it is only in considerable depths that the full effects of atmosphere on light can be made known ; this is especially the case with regard to the selective absorption of light of different colours. The varieties of colour in the sky at sunrise or at sunset, and the golden colour of the full moon at its rising, are due to the transmission of the sun's light through varying thicknesses of air, full of fine particles of matter and of aqueous vapour, which cut off more or less of the blue rays. Higher and higher above the horizon the thickness of the atmosphere diminishes ; more and more blue light of the illuminated haze scattered by reflection mixes with the transmitted light, which gradually diminishes and makes the colour gradually paler until near the zenith. There is no longer any transmitted light, and the colour of the sky is blue, and farther from the sun may be even violet, from the light scattered by reflection. Just as the sodium flame in front of a weaker flame adds to the intensity of the sodium light, so the blue illuminated haze in front of the blackness of space, or even in front of a dark hill, will give the blue colour to the sky, or tinge the hill with blue or violet light.

(To be continued.)

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Sept. 16.		Business Done Week Ending Sept. 16. Highest.		Lowest.	
Anglo-American	30½,	31½	 31	.....	30½	
Do. Preferred	51½,	52½	..... 52½	.....	51	
Do. Deferred	8,	9	..... —	.....	—	
Brazilian Submarine	10½,	11	..... 11¼	.....	10¾	
Cuba	12,	12½	..... 12½	.....	12	
Do. Preference	18,	19	..... 18½	.....	18	
Direct Spanish	1½,	2	..... —	.....	—	
Do. Preference	11½,	12½	..... —	.....	—	
Direct United States Cable	8½,	9¼	..... 9½	.....	8 15-16	
Eastern Telegraph	10¾,	10¾	.....11 7-16	.....	10½	
Do. 6 per Cent. Preference	13½,	13¾	..... 13¾	.....	13½	
Do. 5 per Cent. Debentures, 1899	105,	108	..... —	.....	—	
Eastern Extension	11¾,	12	..... 12¾	.....	11¾	
German Union	8¾,	9¼	..... —	.....	—	
Globe Telegraph and Trust	6¾,	7½	..... 7¾	.....	7	
Do. Preference	12¾,	13½	.....13 13-16	.....	13	
Great Northern	13½,	14	..... 13¾	.....	13¾	
Indo-European	30½,	31½	..... 31½	.....	31	
Reuter's	7½,	8	..... —	.....	—	
Submarine	190	200	 191	.....	190	
West India and Panama	⅝,	¾	 11-16	.....	—	
Do. 1st Preference	8½,	8¾	..... —	.....	—	
Western Brazilian	5½,	6	 6	.....	—	
Western Union 7 per Cent. 1st Mortgage	120,	124	..... —	.....	—	
Do. 6 per Cent. Sterling Bonds	100,	102	..... —	.....	—	x.o.

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	½	.....	⅜	.....	—
Oriental	½,	⅝	.....	5-16	.....	—
United Telephone	11¾,	12¼	.....11 15-16		.....	11¾

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	.....	—	.....	—
Do. (fully paid)	3½,	4	.....	3	.....	2¾
Hammond Light (£3 15s. paid)	1-16	3-16	.....	—	.....	—
Swan	½,	¾	.....	—	.....	—
Maxim-Weston	½,	⅝	.....	½	.....	—

MISCELLANEOUS.

Telegraph Construction	35½,	36½	.....	36¼	.....	36
India Rubber, Gutta Percha, and Telegraph Works	23,	24	.....	24	.....	23½

TRAFFIC RECEIPTS FOR AUGUST, 1885.

Companies.	Aug., 1885.	Aug., 1884.	Increase.	Decrease.
Brazilian Submarine	11,896	—	—	—
Cuba Submarine	2,200	2,515	—	315
Direct Spanish Telegraph	1,276	1,190	86	—
Eastern Telegraph	47,968	45,329	2,639	—
Eastern Extension	41,987	39,463	2,524	—
Great Northern	24,000	—	—	—
Western and Brazilian	7,153	—	—	—

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NOTES.

OBITUARY.—We greatly regret to have to chronicle the death of Mr. John Muirhead, senr., at his residence at Sydenham.

A CURIOUS EFFECT OF LIGHTNING.—Amongst the lepers at the Misken Hané, at Scutari, is one who is said to owe his malady to a lightning stroke.

THE ELECTRIC LIGHT IN CANADA.—The Light Committee of the Montreal City Council propose to consider the question of lighting the streets of that city by electricity.

SANITARY EXHIBITION AT LEICESTER.—We understand that Messrs. Woodhouse and Rawson have put down an installation of arc and incandescent lights in this Exhibition.

THE REVOLUTION IN EASTERN ROUMELIA.—A telegram from Bucharest announces that all strategic points on the Turkish frontier have been occupied by the Roumelian insurgents, the telegraph wires cut, and the bridges destroyed.

NEW TELEGRAPH STATION IN CHINA.—The Great Northern Telegraph Company announce that a new telegraph station has been opened at Chefoo. The rate by this company's lines from all stations in the United Kingdom is 10s. per word.

ANOTHER CENTRAL STATION.—We are informed that the German branch of the Edison Company have applied for a concession to establish at Frankfort a central station for the distribution of the electric light and the transmission of power.

ELECTRICITY AND CHOLERA.—Experiments have recently been made in France with a view to the application of electricity as a curative agent in cases of Asiatic cholera. The results, although interesting, have not yielded unqualified satisfaction.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 11th Sept. were £1,665, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

GOOD INSULATORS.—It is stated that liquid oxygen and nitrogen rank among the most perfect insulators. The resistance of copper decreases much more rapidly than the absolute temperature, and approaches zero at a temperature not very remote from that obtained by evaporating liquid nitrogen in a vacuum.

AN INTERNATIONAL SCIENCE ASSOCIATION.—It has been suggested that the twenty-five thousand dollars given by Mrs. Elizabeth Thompson for the advancement and prosecution of scientific research in its broadest sense should be administered by an International Association of Science. The idea, however, has not found much favour.

THE CHOLERA IN SICILY.—According to a telegram from Rome the advent of the cholera has completely demoralised the Sicilians. As an instance of the way in which they are endeavouring to take the law into their own hands, it is mentioned that at Alexandria della Rocca the railway and telegraphic connections were broken and other outrages committed.

MORE EXHIBITIONS.—The project of a new Electrical Exhibition in Paris has been announced. It is to be held next spring, and will be organised by the International Society of Electricians. Probably it will be a second edition of the exhibition held at the Observatoire a few months ago, with all the modifications and extensions that may be dictated by experience.

THE TELEPHONE AT LYNN, NORFOLK.—The Lynn Town Council have decided to have the town police station connected by telephone with the dock police office, at a yearly rental of £7 per annum, and to accept the offer of the South of England Telephone Company to provide and maintain telephonic communication between the police station and the waterworks, for £13 per annum.

EDISON.—A biographical sketch of Edison appears in the issue of *Science* for August 21, which says that "in his experimentation he is minute and painstaking, noting carefully the phenomena he is investigating, and recording accurately the results. Moreover, he is not only quick to observe facts, but prompt to detect their practical importance, and ready to seize upon such of them as may serve as the basis of an invention."

THE EARTHQUAKES.—Attwenty minutes before eleven o'clock on Thursday morning last week, the seismograph at Naples University registered a shock of earthquake, which lasted eight seconds.—A Reuter's telegram, dated Rome, Sept. 21st, says that repeated shocks of earthquake have occurred in Benevento. The inhabitants are terror-stricken, and are encamped in the open country. Several persons have fled from the province.

AMERICAN TELEPHONE STATISTICS.—The number of telephones in the hands of licensees Dec. 20th, 1884, was 325,574, an increase for the year of 26,994. The increase and decrease by months in the telephone output for the last eight months have been as follows:—Gain: March 60, April 1,691, May 2,442, June 2,411; total 6,604. Loss: January 298, February 594, July 314, August 544; total 1,750. Net output, eight months, 4,854.

THE INDIAN TELEGRAPHS.—The officers of the Indian Government Telegraph Department have commenced an agitation for the relief of their grievances, and have organised a defence committee for the purpose of working their cause systematically. They complain of the stagnation of promotion and of inequitable treatment as compared with other branches of the Government service, and they appear to make out a strong case.

THE CENTRAL STATION AT TOURS.—The Central Electric Lighting Station at Tours will probably be completed in about a month's time. The station is intended to supply current to about 3,000 Oppermann incandescent lamps of 16 candle-power, taking 40 volts and 0·9 ampere. The installation includes a supplementary battery of 50 Kabath accumulators, which will be held in reserve in case of a temporary breakdown of the engine or dynamos.

TELEPHONE FACILITIES IN BELGIUM.—In Belgium a large number of the hotels, cafés, and shops are subscribers to the telephone system, and no charge is made at these establishments for talking, it being supposed that the user will take a small refreshment, which is sufficient to recoup the infinitesimal amount represented by such operation. Of course this facility is invaluable, as it permits people to hold a conversation in any part of the town, and the system is well worked.

POST OFFICE TELEGRAPHISTS AND THE ROYAL ENGINEERS.—The twenty-four Post Office telegraphists still serving at Aldershot with the Royal Engineers are to be re-transferred to the Army Reserve at once. They will resume their duties at the telegraph offices under the Postmaster-General, where they were previously employed, and be re-attached to the 24th Middlesex Rifle Volunteers. They are to be entertained at a dinner in honour of their return at the Holborn Restaurant to-morrow evening.

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THE RIVER PLATE TELEPHONE AND ELECTRIC LIGHT COMPANY.—There is an increase in the number of subscribers to this company in Buenos Ayres and Monte Video from 1,573 on 31st January, 1884, to 1,845 on the 31st January, 1885, and this increase represents a corresponding enlargement of income from £26,112 to £29,226. Later accounts, which are carried down to March, 1885, show that the number of subscribers has been raised to 1,885—the exact number of the year.

MUNRO AND JAMIESON'S POCKET BOOK.—This handy little pocket book of electrical rules and tables, by J. Munro, C.E., and Andrew Jamieson, A.M.I.C.E., F.R.S.E. (London, Charles Griffin and Co.), has reached its third edition. In the copy now before us several important additions have been introduced, among which is a comprehensive appendix on magnetic measurements. For purposes of ordinary reference in the testing room or laboratory this little work is a library in itself.

THE ORIENTAL TELEPHONE COMPANY.—It is believed that the shares of this company, which are of £1 each (11s. paid), will shortly be made 11s. shares fully paid. It will be recollected that the "Consolidated Telephone" shares were treated in a similar way, being "written down" to 15s. They are now at a premium! "Orientals" may, not improbably, rise to par on this becoming known. The company has just received £8,000 from the Government over the Alexandrian indemnity business, and no further calls will now, we understand, be required.

THE ELECTRIC LIGHT IN CHILI, S.A.—In the city of Santiago there are some 2,000 Edison lights being maintained from a central station. In Valparaiso there are 110 Brush lights employed in lighting the General Post Office, hotel dining rooms, billiard halls, and shops. The Brush people have lately exhibited a tower light consisting of five 4,000 candle-power lights, mounted on a mast 65ft. high, which is located on a hill some 200ft. high in the heart of the city. This light is seen at sea over 30 miles away, and similar lights are soon to be employed in lighting the towns of the interior.

THE BLACKPOOL ELECTRIC TRAMWAY.—The inspection of Major-General Hutchinson has resulted in the line being declared fit for public traffic. On Saturday last trams commenced to run by horse-power, and they have since been run by horses and very extensively patronised. The work of clearing out the central channel—which along South Beach was completely full of sand and shingle deposited by the tide—is being carried on as quickly as possible by a staff of men under the direction of Mr. Burnett. Other arrangements are in progress by which it is hoped that the line will be worked electrically on it being formally opened by the Mayor of Manchester, on Tuesday next.

ELECTRIC LIGHT IN TRAINS.—The Pennsylvania Railroad is experimentally lighting nine carriages with incandescent lamps. The current is supplied from a Brush storage battery, carried beneath the carriages. The batteries are charged once a week. Each carriage carries six trays or boxes, each tray containing four cells. The cell gives at first an E.M.F. of 45 volts, and is worked till the E.M.F. falls to 39 volts, when it is recharged. Swan lamps are principally used, though Stanley-Thomson lamps have been tried. The parlour-cars have ten 16 candle-power lamps, the passenger cars but six. The lamps are arranged that half may be switched on or off. A clock mechanism in connection with the wires regulates the time the lamps are on. If only half are on the mechanism of the clock registers the fact.

THE LIGHTING OF THE CITY.—At a recent meeting of the Court of Common Council, Deputy Fry asked the Chairman of the Commission of Sewers whether there was any probability of the electric light coming into use in the City during the coming winter. Mr. Johnson, in reply, said there was little or no such probability. The Commissioners had had the subject before them for two years, and had done their best to get some responsible company or persons to undertake the lighting of the whole or part of the City. They had several times hoped that the difficulties would be removed; but when the time came the companies backed out of their proposals. There might be an attempt to light Billiter-street before long by a private individual who used the electric light in his own large establishment.

UNDERGROUND TELEGRAPHS IN FRANCE.—As already announced in our columns, the underground telegraph line from Paris to Lyons and Marseilles is now completed, and the wires will be used as soon as the instruments destined for them are placed in the offices at Paris, Lyons, and Marseilles. This underground line, added to those overhead, will not only enable messages to be accelerated, but will enable communications to be kept up no matter what the state of the weather may be. Underground lines will also be laid between Marseilles, Toulon, and Nice. Marseilles and Havre are already connected by a direct wire, and this not only secures rapid communications between the two ports, but places Marseilles in direct connection with the United States, as the Marseilles-Havre wire is to all intends and purposes the prolongation of the Franco-American cable which abuts at Havre.

THE AMERICAN BROADWAY RAILWAY.—It is said that the Broadway Underground Railway scheme is assuming such business like shape as to insure the building of the road. The enterprise is one of enormous magnitude, and the six and a half miles now under contract from the Battery to Harlem and its branches will cost, according to surveys and estimates made and carefully supervised by General George B. M'Clellan, 1,200,000dols. to 1,400,000dols. per mile. The entire structure will, we are informed, be continually lighted by electricity, and the trains run by electric motors. Arrangements have already been made with the American Electric Manufacturing Company by which the American company will control the lighting of the great structure, supply the electric motors, as well as for the control of the right for placing telegraph, electric light, telephone, fire alarm, and other wires in the structure.

CONTINENTAL ITEMS.—On the occasion of the return of the troops after the late manœuvres in Bohemia, the station at Smichor was illuminated by ten arc lamps, installed by Messrs. Allmer and Zollinger, of Bubna, near Prague. The installation of the electric light in the Château de Chasse Impérial, at Lainz, near Vienna, is nearly completed. The château and its corridors, offices, &c., will be lighted by 300 incandescent lamps, and a road, two and a-half miles in length, in connection with the estate, is also to receive 130 lamps of the same kind. An engine room has been constructed some seventy yards distant from the château. This contains an engine of 50 h.-p. and four dynamos, two of which latter will supply the current to the lamps in the interior of the building, and the other two to the outdoor incandescents. The installation has been put down by Messrs. B. Egger and Co., of Vienna, well known in connection with the lighting of the new Hôtel de Ville.

CABLEPHONING!—The following story is going the rounds of the non-technical papers:—"The Press Association is

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informed that a discovery has been made in electrical science, by which the problem of telephoning across the ocean through any of the existing Atlantic cables has been practically solved. The inventor has been led to the discovery through the very simple reasoning that if machinery and batteries of given power can convey the sound of the voice a certain distance, more powerful machinery might transmit it further. This theory has been confirmed by experiments with an instrument by which conversation was conducted over 2,300 miles of wire immersed in the Gulf of Mexico." Our *confrères* of the daily press will do well to abstain from swallowing too much of this glowing account of the impracticable. It is all nonsense to talk about machinery and batteries of great power. The carrying capacity of a long cable in regard to strength of current is just as limited as it is in regard to speed, and furthermore no cable company would sanction the use of high tension currents on its lines.

SOMETHING WANTING!—The Bournemouth Improvement Commissioners will never fully justify their title until they reconsider and reverse the decision they have just come to in regard to the installation of the electric light in Bournemouth. At a recent meeting of the Commissioners the Lighting Committee reported that they had considered a letter from Messrs. Laing, Wharton, and Down, asking for a definite answer in regard to the electric light. The committee advised the Board to take no further steps in the matter at present, and with the weakness which but too often characterises the actions of local authorities and so-called "Improvement Commissioners," the suggestion was approved. The following item from the Commissioners' half-yearly estimates will be found of interest: — *Lighting, estimated expenditure, £1,170. 7s. 0d.*, including £274 for lamp lighters' wages, £706 for gas to public lamps, and £110 for new lamps. So the lighting of Bournemouth costs at least £2,340. 14s. a year. Now Messrs. Laing, Wharton, and Down, What will you give them twice the amount of light at, per annum?

SUBMARINE EARTHQUAKES.—The schooner "Rosario," at New York, has reported that on the 23rd of last June, in lat. 29° 14′ N., long. 133° 35′ W., at 11 a.m., two heavy shocks of a submarine earthquake were experienced. These occurred at an interval of about sixty seconds; the last being much more violent than the first, and causing the ship to tremble violently. It is stated that the sea was remarkably smooth. Some of our readers may remember several shocks of the same kind have from time to time been experienced along the east coast of Africa. The Mozambique-Delagoa Bay section of the Eastern and South African Company's cables has been buried on two occasions either by volcanic or alluvial masses, and has had to be broken out of the sea bottom before the necessary repairs could be effected to it. The disturbances travelled north and south. A similar occurrence was not long ago reported by the commander of the German gunboat "Prinz Adelbert." Whilst lying in the roadstead of Aucon on the 10th of February last two short earthquakes were felt which lasted ten seconds, and were noticed very perceptibly on board ship. These also travelled north and south, and like the others of which we have spoken did little or no damage on shore.

WEST AFRICAN CABLES.—On Tuesday last the India Rubber, Gutta Percha, and Telegraph Works Company's ss. "Silvertown" arrived at the moorings off the works at Silvertown, and the shipping of the above-mentioned cables was commenced. These cables are destined to place the Cape Verde Islands in telegraphic communication with various points along the West Coast of Africa, and the system will be duplicated by connecting these points with the Spanish National Submarine Telegraph Company's station at St. Louis (Senegal). About 1,350 nautical miles of cable will be shipped, forming the first portion of a system of telegraphic communication to be carried out along the West Coast of Africa under concessions granted by the French and Portuguese Governments. The present expedition has for its immediate object, on the one hand, starting from the Cape Verde Islands, and on the other from St. Louis, to connect up and establish stations at the following points: — Dakar (Senegal), Bolama and Bissau (Portuguese possessions, about 250 miles to the south of Bathurst), and Rio Nunez or Conakry (French settlements, the latter about 80 miles to the north of Sierra Leone). The ss. "Silvertown" will probably leave for the West Coast about the first week in October.

A MANUAL OF TELEGRAPHY.—"A Manual of Telegraphy," written by Mr. W. Williams, M.S.T.E. and E., a superintendent in the Indian Government Telegraph Service, and published by Longmans, Green, and Co., has just been added to the existing works upon the subject. The manual, we believe, was written by order of the Director-General of Telegraphs in India, and is based on the substance of the papers on technical subjects set by the author at the general examinations of the Indian Telegraph Department. These subjects embrace a general description of the various instruments, batteries, and circuits which the telegraph official may be called upon to deal with; faults which may be met with, and their remedy; the conservancy of and modes of testing lines; batteries, instruments, lightning conductors, and earths; the general principle of telegraph working in its various forms; the electrical phenomena which interfere with communication, and the various methods by which their obstructive effect is overcome. We have no hesitation in recommending this work to our readers. Exception may be taken by some to the nomenclature and notation, which are identical with those adopted by the late Mr. Schwendler, but the book is a thoroughly good and valuable one.

THE TELEGRAPHS IN THE FAR EAST.—A telegram from Calcutta, dated 20th September, says the Indian Government has received news that the telegraph line is to be extended to Bokhara and to Merv. The Russian telegraph system is now so near to India that it would be a comparatively easy task to join it to the Indian system, thus giving an overland line from Calcutta to Europe. If only the Ameer could be induced to ask for lines to Cabul and Candahar, the Indian telegraph department could construct them without difficulty, and an important step would have been taken towards the establishment of a through overland line. Even if a through line were not yet carried out, still it is impossible to overestimate the importance of having direct communication between the Viceroy and the Ameer and between the Ameer and the Governor of Candahar, while a telegraph station at the latter place would enable news from Herat to reach India in three days, supposing the post messengers travelled only five miles an hour. If a portion of the breathing time which we seem likely to have before the next Russian advance were spent in making these lines, and in constructing the earthwork for a railway from Chaman to Candahar, we could then await the further development of the Central Asian question with more equanimity than will be possible in the absence of such precautions.

SOME AMERICAN NOTES.—The City Council of Davenport propose to light the city with electricity, and will advertise for tenders.—Two new electric lighting companies have been organised in New York, the points of operation, however, to be in Massachusetts. The first is to be known as the American-

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Edison Illuminating Company of Worcester, Massachusetts, and the other having similar name, but for operation in Lowell, Massachusetts. The companies have capital respectively of 100,000 dols and 50,000 dols. The contract made recently by the American Company, of New York, to light the entire city of Portland, Me., in which the American Company will use a large number of the Edison municipal incandescent lamps, was the initial work under the American-Edison compact made in the early part of the summer. Central lighting stations are now to be introduced into Worcester and Lowell, Mass., and it is understood that the American Company is now laying its plans for general street lighting in every city in New England.—In a trial on the Ninth Avenue Elevated Railroad, in New York city, the Daft electric motor has, it is said, run at a speed of 25 miles an hour.—The Commission on putting electric wires underground in Brooklyn, New York, has decided that the law does not apply to wires owned and controlled by the city. The Commission will not prevent any extension of overhead wires by the American fire department.

SIXPENNY TELEGRAM REGULATIONS.—Yesterday's *Standard*, after sharply criticising the new regulations as ambiguous, contradictory, and vexatious, attributes them to "the pedantic idea that a telegram must be transmitted as a facsimile of the original, copied with Chinese fidelity and lack of intelligence." We ourselves have expressed the opinion that some of the regulations complained of will have to give way to simplicity; but it is not a matter of congratulation that in obeying the demand for a popular tariff the Telegraph Department is compelled in self-defence to either enforce strict regulations for counting, or to abandon all fidelity in transmission. Up till now it has been a matter of principle with English telegraphy that the sender's message shall reach its destination, textually at least, in facsimile; and assuredly there would have been a great outcry if the Post Office had systematically taken liberties with the text to avoid cumbersome signals. This, it appears, is henceforth to be called Chinese stupidity, and sixpenny laxity is to be the rule. We foresee that in a short space of time there will be no rules and no counting worth speaking about—and, consequently, no fidelity, Chinese or other, to the text. It is the inevitable law of the cheap and nasty; but it will bear rather hard upon people who do wish their telegrams to be accurately reproduced, and who neither for love nor money will be able to get the thing done.

CHARTERHOUSE SCIENCE AND ART SCHOOLS AND LITERARY INSTITUTE.—The winter session of this, one of the largest science and art schools in the United Kingdom, will, under the presidency of the Rev. Henry Swann, M.A., commence on Saturday, 3rd October. During the late session about 800 students, mostly elementary teachers, availed themselves of the privileges afforded by this institution, and of this number upwards of 500 presented themselves for examination, and were successful in obtaining a large number of first class certificates, and also a goodly number of honours certificates awarded by the Science and Art Department of South Kensington. The only Royal Exhibition taken by a London student this year was by a member of this science school. At a very nominal fee instruction of a practical character is given in most of the sciences; whilst in art, at an equally low rate, students, under the direction of five competent instructors, can be advanced in their studies. Those desirous of studying art in the daytime can do so. Students, who aim at becoming proficient in chemistry (organic or inorganic) have the opportunity of working in a well-fitted laboratory, capable of accommodating 60 students. Aspirants for university honours can at a small expense be assisted in their studies. Lessons in Latin, Greek, French, German, and music are given by well-qualified teachers. Classes for the study of photography and watchmaking, &c., will be commenced this session. Full particulars can be had of the organising secretary, C. Smith.

LIGHTNING AND TREES.—The following letter appeared in *The Times* of the 23rd inst.:—"I shall be pleased to give testimony to one or two facts with reference to the subject of various letters which have recently appeared in *The Times*. During surveys in the forests of the United States, when I necessarily lived under canvas, I often had the opportunity of witnessing the effects of lightning on trees, and my experiences lead me to believe that trees are only destroyed by lightning where they have been previously wetted by rain. A sojourner in the woods, whether he is taken in pursuit of game or with the object of prospecting timber, minerals and land, is always careful to erect his tent under a short thick tree in order to escape the danger of lightning or of trees falling and bringing down others in their way on him; and it was often while thus situated I noticed after stormy nights when lightning and thunder were accompanied by rain that many trees had fallen. The report of the snapping of the trunks would remind one of that of the firing of a cannon, and when lightning and thunder were not accompanied by rain (in the immediate locality of our camp, at any rate) no trees had been struck. I infer from the same observations that the lightning always strikes the tallest trees, whatever their specie may be, for the taller white pines and poplars were most often seen destroyed and the shorter maples, linden, birch trees, &c., rarely so; also that the sap between the wood and the bark of the tree does not increase the chance of its destruction."

ELECTRIC RAILWAYS IN AMERICA.—The Boston *Advertiser* thus summarises the workings of the electric railways in Baltimore and Cleveland:—"Electric motors for street railways are proving successful in Baltimore and Cleveland. The systems are different. The one in Baltimore has a central rail, insulated from the ground, but thus far exposed on the surface. Dogs and horses are occasionally shocked by it. There is talk of enclosing it. The motors used are the Morse and Faraday. One weighs about 4,500lb., and will haul a full horse car four miles in 25 minutes, most of the way up-hill, and some of it steep. The dynamos, of which there are two, are driven by a 35 horse-power engine. Each dynamo is of 50 horse-power, and one suffices for ordinary traffic. The Bentley-Knight railway in Cleveland differs from this in the respect that the electricity is conducted from the dynamo by a stationary cable in a conduit under the track, and through an opening in the top an electric brush reaches down from each car, taking up the electricity to a small motor under the car, from which bands run to pulleys on the axles. The inventors make the following estimates for five miles of double track and the operation of forty cars:—Estimate for newly constructed lines: Cost of horse road, 162,000 dols.; cost of electric road, 344,100 dols.; cost of cable road, 414,750 dols. Annual expense of motive power for horse road, 102,960 dols.; for electric road, 30,551 dols. 50c.; for cable road, 70,500 dols. Annual saving in cost of motive power: Electricity over horses, 72,408 dols. 50c.; electricity over cables, 40,038 dols. 50c.

THE TELEGRAPH AND THE BRITISH ASSOCIATION MEETING.—During the late meeting of the British Association the

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instrument room of the Aberdeen Telegraph Office was each evening the scene of very active operations. From the first meeting of the Association till Wednesday night there were despatched from Aberdeen no fewer than 424,916 words, equal to about 212 columns of printed matter. The great bulk of press messages were despatched during the evening between six and ten o'clock, and in every case the news wires were cleared by half-past ten. There were two wires direct to London, one through Edinburgh, Glasgow, and Belfast, terminating in Dublin; another circuit extended along the west coast of England, supplying *en route* Glasgow, Manchester, Birmingham, Liverpool, and Bristol. Similarly along the east coast there was a wire to Dundee, Edinburgh, Newcastle, York, and Hull; while another circuit connected the midland counties, and included Bradford and Sheffield. In addition to all these, there were two wires exclusively for Glasgow and Edinburgh. It is also due to the efficiency of the operators at Aberdeen to say that the work has been done with wonderful accuracy—an accuracy which has warranted favourable comment from the leading metropolitan journal, as shown by the following remark in the letter of its correspondent in Thursday's issue:—"During the week a great increase of duty was imposed on the telegraph and Post Office officials, but the local staff performed their duties without a hitch. In particular to the telegraph department the Press owes its acknowledgments for the accuracy and despatch with which the many long and often difficult telegrams were despatched to London and elsewhere." We are glad to be able to add our testimony to that of our contemporary.

THE ANTWERP EXHIBITION AWARDS.—The awards, which were officially proclaimed on Monday, the 14th inst., in the presence of King Leopold II., are as follows for the 4th Section, Classes 84 to 103, "Electricity." *Diplomas of Honour:* Germany—Felten and Guilleaume; Heilmann Ducommun. Austria—Ganz and Co. Belgium—Administration des Télégraphes de l'Etat Belge; Compagnie Générale d'Electricité de Bruxelles; J. Jaspar; l'Electrique; Montefiore-Lévi; Schuckert; Bouckaert and Co.; Schubart (Theodore); Van Rysselberghe; Mourlon and Co. France—Menièr; L. Mors; J. O. Mouchel; Gaston Planté; Société Générale des Téléphones de Paris; The India Rubber, Gutta Percha, and Telegraph Works Company. Italy—Société Electro-Métallurgique Italienne. *Gold Medals:*—Germany—Hartmann and Braum; Spiecker and Co. Austria—Dr. Ochorowicz. Belgium—Ch. Alker; Bell Telephone Manufacturing Company; Compagnie Belge du Téléphone Bell; Veuve Ch. Devas; Flamach frères; H. Pieper; Richez and Co.; Ville de Bruxelles. France—P. Barbier and Co.; Arsène Boivin; Cance; L. Clémandot; Houry; Aboilard and Co.; Scrive Hermite and Hermite. Switzerland—Société d'Exploitation des Câbles Electriques. *Silver Medals:*—Germany—G. Lorenz; F. Heller; E. Leybold; Vennemann. England—Saxby and Farmer; Shippey Brothers. Belgium—V. Bartelous; Em. Closset; Alph. Dupont; Société Anonyme des Forges; Usines et Fonderies de Gilly; Léon Kelner; P. Lippens; Fred. Leduc; Clément Ommegang; Eng. Raikem; Léon Van Overstraeten. France—Em. Barbier; E. Cauderey; Delisle and Co.; A. Chertemps and Co.; Ch. Goodwin; Em.-Em. Lévy; J. Vernon. Italy—Cruto. Besides these 26 bronze medals and 18 certificates of honourable mention have been awarded in this Section.

THE POST OFFICE TELEGRAPHS.—To meet the extra demand anticipated upon the adoption of the sixpenny telegram rate, three new trunk lines of wire have been erected; the first from London *viâ* Peterborough, Doncaster, York, and Darlington, to Newcastle; the second from London, *viâ* Aylesbury, Widnes, Leamington, then north of Birmingham to the west of Chester, half-way between Manchester and Liverpool, through Wigan and Lancaster, to Carlisle; the third over the London and South Western Railway to Basingstoke, through Andover and Salisbury to Exeter and Plymouth. There are branches at various points from the main circuits. Similar extensions on a smaller scale have been made in Scotland, Ireland, and other places. Submarine three-wire cables for service under water have also been provided for the use of the Channel Isles, the Isle of Man, and the Orkney and Shetland Islands. About 20,800 miles of new wire have been erected on the new poles. At the various offices in London, and the districts of London where pneumatic tubes take the place of working by wire, an additional four miles of tubing will be used to meet the pressure. A new tube room has been specially prepared in the basement of the Central Telegraph Office. An additional number of 40 Wheatstone automatic telegraph instruments have been purchased. These instruments, which are of the latest and most improved pattern, are capable of telegraphing upwards of 300 words per minute. The following instruments have also been purchased:—Eight quadruplex and 300 duplex sounders, 350 single current sounders, 150 single needles, and ten repeaters. These are in addition to the duplex system, which will be completed in the case of 100 circuits. To work this enormous increase the staff in the United Kingdom will be augmented, as we stated some months past, to the extent of 1,200 telegraph clerks and over 1,000 messengers.

THE T. T. MOTOR!—Prof. Trowbridge has reported favourably upon the wonderful Patent Triple Thermic Water Vapour bi-Sulphide of Carbon Motor. We are to have no more steam as soon as the T. T. W. V. b-S. C. M. takes its proper place in the scientific and commercial world.

No more, "Steam," no more!
The word is spoken.
The spell attached to thee,
O "Steam," is broken.
Thy deeds may live, perchance,
On History's paper;
But now thou art exchanged
For water vapour.
The mighty steam which set
The wheel revolving
Is dead and gone
Or fast resolving.
Resolving into air,
Its final caper.
By parent carbon run to earth
(Bi-sulphide vapour).

Mathematical Chorus:

Sing hey for T – T1 H1,
And set the two last o'er cap T;
If T and T_1 are the temperatures,
You'll get the efficiency—see?

Every body municipal
Should acquire the potent Triple
Thermic motor! thermic motor!
Bi-the-carbon-sulphide cheap,
E'en the cripple, e'en the cripple,
Get a lump, and get a "kittle,"
Generate a triple—thermic leg
Before he goes to sleep.

Chorus by the General Public:

For we've finished with steam;
'Tis absurd, it would seem,
To continue its use in a motor.
Bi-sulphide of carbon in vapourous form
Is the stuff for the new thermic stoker.

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A MERCURY CONTACT COMMUTATOR OF CONSTANT RESISTANCE.*

BY PROF. J. VIRIAMU JONES.

My attention was drawn two years ago to the construction of low resistance and constant resistance commutators of the form to be described by two needs :—

1. For lecture purposes in connection with induction experiments it occurred to me that it would be advantageous, for instance, in such an instrument as Delezenne's circle to do away with the brass spring contacts and substitute mercury contacts.

2. For experiments on the resistance of electrolytes that become polarised a commutator of constant resistance capable of successive quick reversals is a desideratum.

The first commutator of the kind I constructed is a simple extension of the old Siemens split ring commutator, but instead of using one split ring I use two, parallel, coaxal, and similarly placed, the halves being cross-connected. Commutation takes place twice in each complete revolution when the lines of separation of the half discs pass through the mercury cups in which the lowest part of the outside circumferences of the rings turn. The instrument will be readily understood from Fig. 1.

This for simple experiments in induction of electric currents is a very useful low resistance commutator; if it be adjusted to a coil rotating even in a weak magnetic field the current may, if the resistance of the rest of the circuit is very small, be considerable.

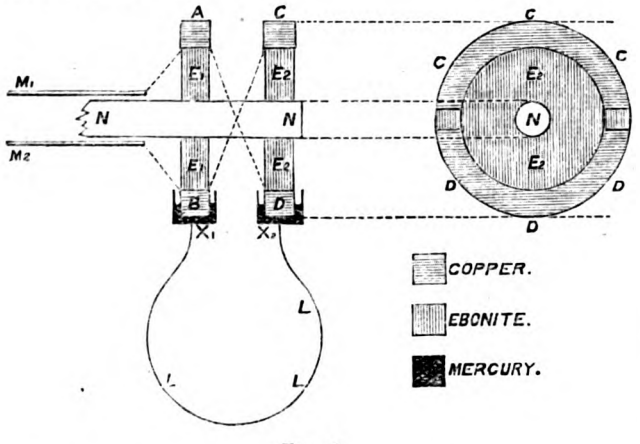

FIG. 1.

M_1, M_2, ends of wire of coil rotating on axis N N, in earth's or other magnetic field.
E_1, E_2, ebonite discs, each disc being surrounded by a split copper ring.
A, B the halves of copper ring on the first disc.
C, D the similarly situated halves of the copper ring on the second disc.
N, N axis of rotation.
X_1, X_2 mercury cups.
L, L, L external circuit.
M_1 is connected by copper wire with half ring A.
M_2 is similarly connected with B.
A and D are connected; and so also B and C.

With two other discs (not split, but complete) added, we have a commutator suitable for the second purpose, a commutator of constant resistance such as is required in measuring the resistance of electrolytes. The arrangement is indicated in Fig. 2.

When the commutator is continuously rotated the current (constant in direction through galvanometer) is reversed twice per revolution through the electrolyte, the resistance of the circuit being undisturbed by the commutator.

If it is required to produce more frequent reversal of the current, it may readily be done by a suitable modification. For instance, if we wish to reverse six times per revolution it is only necessary to have the rings on E_1 and E_2 split each into six parts, to cross-connect these, and to connect the first, third, and fifth segment on E_1 with the complete ring on E_3, and the second, fourth, and sixth segment on E_1 with the complete ring on E_4. The connections are shown in Fig. 3, where to make them plainer the discs are supposed removed from the axle and laid flat.

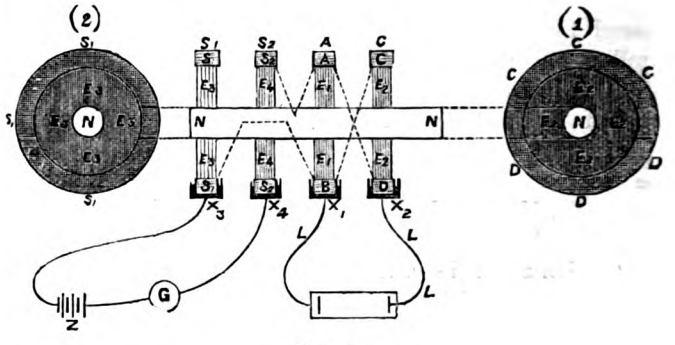

FIG. 2.

Z battery.
G galvanometer.
E_1, E_2, E_3, E_4 ebonite discs; E_1 and E_2 having on their circumference split rings (1); E_3 and E_4 being surrounded by whole rings. (See 21).
A, B the half rings on the first disc.
C, D ,, ,, second disc.
S_1, S_2 the complete rings on the third and fourth discs.
N, N axis of rotation.
X_1, X_2, X_3, X_4 mercury cups.
L, L, L circuit containing the electrolyte.
The connections between the different parts of the commutator are indicated by dotted lines, thus—

S_1 is connected with B.	A is connected with D.
S_2 ,, ,, A.	B ,, ,, C.

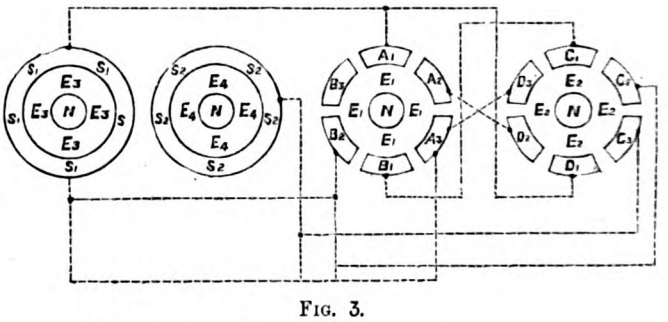

FIG. 3.

A_1 is connected to D_1.	B_1 is connected to C_1.
A_2 ,, ,, D_2.	B_2 ,, ,, C_2.
A_3 ,, ,, D_3.	B_3 ,, ,, C_3.

Also A_1, A_3, B_2, are connected to S_1; and A_2, B_1, B_3 to S_2.

As a further illustration of the utility of the method, we will take an arrangement which is of great convenience in adjusting resistance coils by Wheatstone's bridge.

Taking the following figure from Maxwell (Vol. I., p. 440)

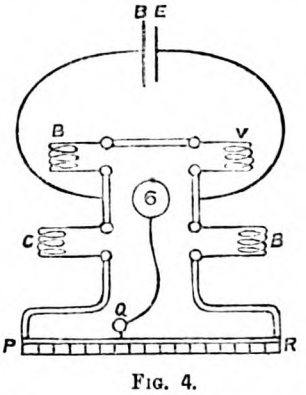

FIG. 4.

β is supposed to be a standard resistance coil, and we wish to adjust γ to be equal in resistance to β.

In making the measures it is requisite to reverse the direction of the current through β and γ; then to interchange β and γ

* "On a form of Mercury Contact Commutator of Constant Resistance for use in adjusting resistance coils and for other purposes." Abstract of Paper read before the British Association.

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and to reverse the direction of the current in the new position. All this may be done by an arrangement of eight parallel coaxal ebonite discs, each having on its circumference a split ring, the rings being properly arranged relatively to one another and proper connections being made between the segments.

In Fig. 6 the connections are shown, the discs being supposed for simplicity of drawing removed from the axle and laid flat.

In Fig. 5 we see the general arrangement, the connections between the segments being omitted.

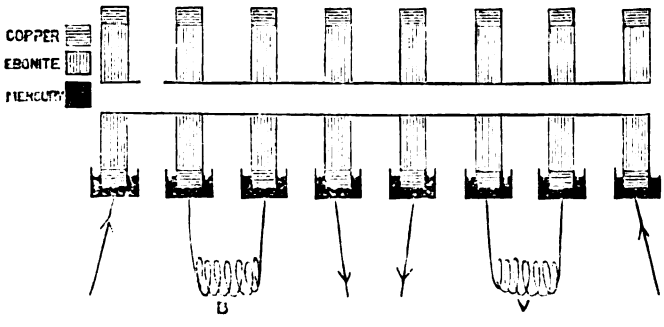

FIG. 5.

Turning through a straight angle from the position indicated in Fig 6 reverses the direction of the current through β and γ. A second turn through a right angle interchanges the coils; a third turn through a right angle reverses the direction of the current through the interchanged coils; and a fourth turn through a right angle brings the instrument back to its original position, again interchanging the coils.

The same commutator is useful in adjusting resistance coils by the differential galvanometer method.

In describing the apparatus I have ommitted details of construction, and one or two points in regard to the mercury cups, which are of importance.*

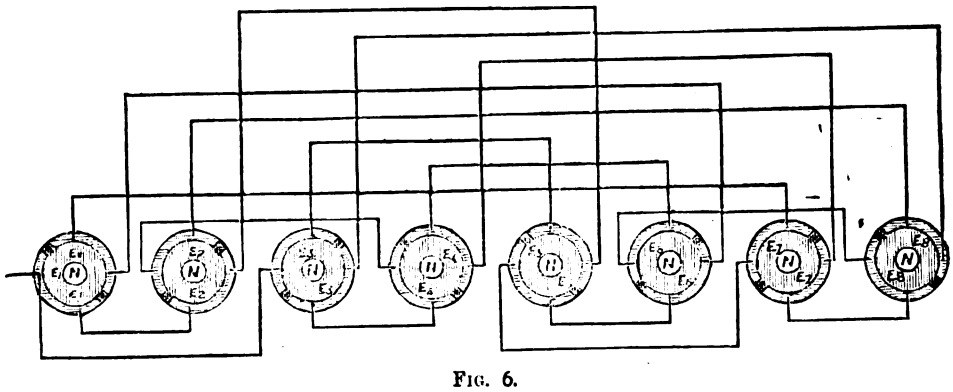

FIG. 6.

E_1 E_2.....Ebonite discs, each having on its circumference a split ring of copper. They are in the instrument arranged coaxially and parallel. The line of segmentation of E_1, E_4, E_5, and E_8 are parallel to each other and at right angles to those of E_2, E_3, E_6, and E_7. The connections are as indicated by the lines.

ON THE DEVELOPMENT OF THE PNEUMATIC SYSTEM AS APPLIED TO TELEGRAPH PURPOSES.†

BY J. W. WILLMOT.

It is probably not generally known by what means telegraphic messages are collected from the branch offices in large towns and conveyed to the central office for transmission by wire.

This service is performed by means of pneumatic tubes, through which "carriers" containing the actual written messages are propelled—in one direction by compressed air, and in the opposite direction by rarefaction of the air in the tube. A specimen of the carriers used may be seen on the table. (See diagram on next page.)

The system was first introduced by Mr. L. Clark, in 1854, who employed vacuum, drawing the carriers in one direction only. The first tube which came into operation was laid for the Electric Telegraph Company, between their office in Lothbury and their branch office at the Stock Exchange. This tube was in continuous use for over twenty years, and from a piece which I have here it will be seen that, beyond the inner surface being polished, the pipe is very little the worse for the service it has seen.

About the year 1866 Mr. C. F. Varley applied compressed air for propelling the carriers in the opposite direction from that in which they were drawn by vacuum, and very ingenious valves were at that time designed by him for effecting the necessary changes in the direction of the flow of air through the tube. With each of the foregoing systems it was necessary after the transmission of a carrier to restore the pressure in the tube to the normal atmospheric pressure before another carrier could be despatched. This caused considerable delay and loss of engine power.

In 1870 the author designed the double-sluice valve which is now in general use, and by means of which carriers can be despatched continuously without stopping the flow of air in the tube. The sectional and other diagrams fully explain how this is accomplished, the principle being that the upper sluice shall be closed before the lower one is opened and *vice versâ*. The employment of pneumatic tubes in London has been continually increasing, until the system, which in 1854 was represented by one 6 horse-power engine working a single tube a few yards in length, at the present time comprises four 50 horse-power engines (each indicating 130 horse-power) and forty-nine tubes, the aggregate length of which exceeds twenty-seven miles. These figures are exclusive of over a mile in short lengths of house tubes, also worked by the engines, as well as of over a dozen hand-worked tubes in various metropolitan offices.

The use of pneumatic tubes, however, has not been restricted to London alone. Each town, as it has become telegraphically important, has been provided with a pneumatic system. A list is appended, giving particulars of engines and tubes at present in use at the various important cities and towns of the United Kingdom. From this it will be seen that there are in London and the provinces one hundred and twelve tubes having a total length of over thirty-nine miles, and requiring fourteen engines, having a total of 364 (nominal) horse-power to work them. To these should be added, in order to fairly represent the pneumatic system, 95 shorter hand-worked tubes fitted at various less important places. With the air pressure employed—ten pounds pressure and eight pounds vacuum—an approximate speed of one mile in 70 seconds is attained in tubes not exceeding a mile in length. The speed varies inversely as the square of the length of the tube.

The pipes generally employed are of lead, having an internal diameter of 2¼in. These pipes are carefully drawn, and are joined together by means of a plumber's joint, made upon a heated steel mandril, which is drawn out by means of a chain after the joint has been made. The lead tubes are protected by being laid in ordinary cast-iron socket and spicket pipes. In view of the anticipated increase in the number of

* The mercury cups are provided with copper strips, against which the rings rub lightly during rotation.

† Paper read at the Aberdeen meeting of the British Association.

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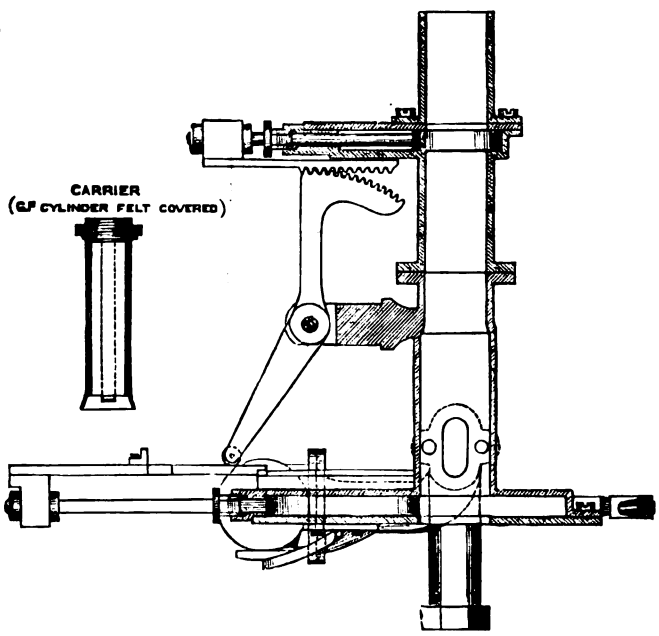
messages which will result from the introduction of the six-penny telegram tariff, considerable extension of the existing pneumatic system has been made at several places, more especially at Liverpool. At that place six new tubes have been laid, and three 30 horse-power beam engines (each indicating up to 90 horse-power) have been erected. Of these engines two are kept working and one as spare. They were designed and constructed under the personal supervision of the author, and were made by Messrs. Easton and Anderson, of Whitehall-place, London, and Erith, Kent. The following is a detailed description of their general arrangement :—

The machinery, as shown by the diagram on the wall, consists of three engines, each working two pneumatic pumps, any two engines being capable of doing the full amount of work required. The third engine is kept in reserve. Steam is supplied from two multitubular Cornish boilers, one boiler being sufficient to work at one time. The engines are high-pressure condensing beam engines, and are completely self-contained on one continuous cast-iron bed-plate. The beam, which is cast iron, is supported by two A frames of box section, bolted on to the bed-plate. These also carry the entablature round the beam. The bed-plate itself is bolted down to brick piers. Placed under each extreme end of the beam, and connected to the air and vacuum mains, is a double-acting air pump of 2ft. diameter



Willmot's Pneumatic Double Sluice Valve.

and 3ft. 11in. stroke. At top and bottom of each pump on one side is a nest of valves, which valves open outwards, and on the other side are valves similarly arranged, which open inwards. On the passages between the valves and the pneumatic mains is a three-way sluice communicating either with pressure or vacuum mains, or with the atmosphere. Thus it will be seen that if the sluice on that side of a pump on which are the valves which open inwards be open to the atmosphere, while the sluice on the opposite side is open to the pressure mains, the pump will take by suction from the air, and deliver air after compression into the pressure main. Similarly, if the sluice on the inlet side of the pump be open to the vacuum main, while the sluice on the opposise side is open to the air, the pump will exhaust from the vacuum main and deliver to the air. Consequently the pumps are interchangeable, and may be worked at will for either pressure or vacuum. This arrangement is very simple, there being only two sluice valves on each pump instead of four, as in some other instances. Each pump is provided with a 2in. relief valve, so that the change from pressure to vacuum may be made while the engine is running, without unduly raising the pressure in the pumps. The pressure and vacuum pump valves are of leather, each valve having an area of ten square inches.

List showing the Metropolitan and Provincial Pneumatic Tube Systems.

From	To	Number and Description of Engines.	Length of tubes in yds.	Total Length.
LONDON :				Miles yds
G.P.O.	House of Commons (W. Strand intermediate).	Four, each 50 h.-p. condensing, three working and one spare.	3873	
	West Strand		2548	
	Lower Thames-street (2).		3682	
	Stock Exchange (2)		2170	
	Submarine Company (2).		2592	
	Gresham House (2)		2578	
	Leadenhall-street (2)		2654	
	Mark-lane (2)		3070	
	General Post Office		157	
	Telegraph-street		917	
	Anglo-American Co.		1032	
	Founder's-ct., Lothbury.		834	
	G. N. Telegraph Co.		1168	
	Lloyd's (Cornhill intermediate).		1226	
	Baltic Coffee House		1192	
	Eastcheap		1417	
	Seething-lane		2088	
	Ludgate-circus		777	
	Smithfield Market		728	
	Fleet-street (2)		2219	
	Paris and New York Co.		1034	
	Western Union Co.		1010	
	Direct Spanish Co.		1083	
	Eastern Telegraph Co.		1107	
	Hatton-garden B.O.		927	
	Gracechurch-street B.O.		1280	
	Queen Victoria-st. B.O.		644	
	Throgmorton-av'nue B.O.		1210	
	G.P.O. house tubes (29).		1824	
	Submarine Co. (spare)		1282	
	G.P.O. (spare)		157	
	Angel-street (spare 4)		400	
Submarine Co.	Threadneedle-street		672	
Royal Exchange	Threadneedle-st. (spare).		60	
Fetter Lane	Fleet-street (spare 2)		130	
Poultry	Lombard-street (spare 2).		171	
Princes-street	Moorgate-street (spare 2).		40	
	Number of tubes, 78.			28 773
LIVERPOOL :				
H.P.O.	Royal Exchange (4)	Three, each 30 h.-p. condensing, 2 working and 1 spare.	3164	
	Victoria-street (2)		1742	
	Corn Exchange (2)		1320	
	Stock Exchange		800	
	News Rooms		820	
	Ranelagh-street		740	
	Lime-street		1170	
	Counter		60	
	Delivery		60	
	Number of tubes, 14.			5 1076
MANCHESTER :				
York-street	Thomas-street	2, each 10 h.-p., 1 working & 1 spare.	725	
	New Exchange		451	
	Stock Exchange		413	
	Mosley-street		300	
	Head Post Office		225	
	Number of tubes, 5.			1 354
BIRMINGHAM :				
Exchange-bldngs.	New-st. Railway Station.	One 6 h.-p.	140	
	Cannon-street		240	
Head P.O.	Cannon-street		537	
	Number of tubes, 3.			917
GLASGOW :				
H.P.O.	Royal Exchange	One 20 h.-p.	270	
	Stock Exchange		510	
	Argyle-street		1046	
	Waterloo-street		838	
	Counter		34	
Argyle-street	Waterloo-street (spare)		270	
	Number of tubes, 6.			1 1208
NEWCASTLE :				
H.P.O.	Quayside	1 8 h.-p		460
	Number of tubes, 1.			
DUBLIN :				
G.P.O.	College Green	Two each 10 h.p. 1 working & 1 spare	715	
	Four Courts		1214	
	Custom House		679	
	Delivery		56	
	Counter		50	
	Number of tubes, 5.			1 954
	Total number of tubes 112.			39 462

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The steam cylinder is 18in. in diameter, with 2ft. 7in. stroke, steam jacketed, and lagged with felt and teak in the usual way. It is placed between the rear pump and the main A frames. The main slide valve is worked from an ordinary excentric on the crank shaft, but the expansion slide has an independent motion from the beam. A wrought iron lever is pivoted on a casting on the entablature frame, one end of the lever is connected by a link to the beam, while the other is connected to the expansion valve spindle, which passes through a bow bracket on the top of the slide chest cover; a bevel pinion on the slide rod gears into another small pinion in connection with a hand wheel carried by means of the above-mentioned bow bracket by which the expansion may readily be varied while the engine is running. The steam starting valve and injection cock are in close proximity, so that the engine man has all the means of regulating his engine close at hand.

The air pump and condenser are fixed underneath the bed plate. The former is bolted to the bed plate and is worked direct from the beam by the same system of parallel motion as the engine piston and pump rods. The condenser is of the ordinary "jet" description. In event, however, of shortness of water for condensation, provision has been made for working the engines non-condensing, exhausting the steam into the chimney shaft. As, however, arrangements are being made to cool and circulate the condensing water, it is only in very exceptional circumstances that it will be necessary to work non-condensing. The connecting rod is of cast iron, with the same stroke of crank as that of the piston. The entablatures which surround each beam are connected together, and are reached by a wrought iron stair from the engine room floor.

The two steam boilers are of the multitubular Cornish type, 6ft. 6in. in diameter and 20ft. 1½in. long, with double flues, the flues terminating in seventy-four tubes 3in. diameter and 6ft. long. The boilers are set on cast-iron chairs, with a return flue first underneath the boilers, dividing in front and returning along either side to the back, where the draught enters the main flue to the chimney shaft. The boilers are of mild steel throughout, and have been tested with hydraulic pressure up to 150lb. on the square inch to work at 70lb. steam pressure. It was found in working that one boiler was quite capable of providing steam for the two engines with the damper partially closed; on opening the damper the steam very soon began to blow off at the safety valves. The boilers are fitted with double dead weight safety valves and all other fittings required by steam users. For the supply of feed water each boiler is fitted with an injector, and in addition there is a donkey pump connected to both boilers.

The engines here described are situated in an engine-house, 320 yards distant from the Liverpool Head Post Office, with which they connected by two air mains, 12in. in internal diameter. These air mains consist of cast-iron pipes with carefully fitted male and female flanged joints. The joints are packed with thick vulcanised rubber rings between the flanges to allow for contraction and expansion of the pipes, and are perfectly air tight with an air pressure of 30lb. to the square inch.

REPORT OF THE STANDARDS COMMITTEE OF THE BRITISH ASSOCIATION.

The Committee report that during the year the standards of resistance, in terms of the legal ohm referred to in the last report, have been constructed, and their values determined in accordance with the resolution adopted on June 25, 1884.

The one ohm standards were generally referred to the original B. A. units of the Association by combination in multiple arc with the standard resistance of the 100 B. A. units, and determining by Carey Forster's method the difference between the combination and a single B. A. unit, and then assuming, in accordance with the resolution, that

1 B. A. unit = ·9889 legal ohm.

The following values were thus found for the two standards. The temperatures were taken by a thermometer graduated to tenths of a degree C., which had been compared with the Kew standards.

Resistance coil—Elliott, No. 139, (B.A. No.)100.

Date.	Temp.	Resist.
Nov. 24, 1884	11·4	·99878
,, 26 ,,	11·6	·99890
,, 27 ,,	12·9	·99916
,, 28 ,,	12·9	·99930
Dec. 5 ,,	13·5	·99931
,, 12 ,,	15·3	·99979
July 30, 1885	17·2	1·00027
,, 28 ,,	18·1	1·00061

Mean value ..... ·999515 at 14° C.
Temperature coefficient.. ·000250

Resistance coil—Elliott, No. 140, (B.A. No.)101.

Date.	Temp.	Resist.
Nov. 24, 1884	11·4	·99825
,, 25, ,,	11·5	·99827
Dec. 2, ,,	12·8	·99847
Nov. 27, ,,	12·9	·99851
Dec. 5, ,,	13·4	·99865
,, 12, ,,	15·4	·99917
July 30, 1885	17·2	·99961
,, 29, ,,	18·0	·99983

Mean value ..... ·998845 at 14·1°C.
Temperature coefficient.. ·000238.

The ten ohm standards were then compared with the one ohm by means of the arrangement suggested by Lord Rayleigh, and described in the report for 1883, and from these values were obtained for the coils of higher resistance. The results are contained below :—

No. of coil.	Resist.	Temp.
141 (B.A. No.)102	10·00415	16·7
142 103	10·00352	16·75
143 104	100·0304	16·05
144 105	100·0436	16·05
145 106	1000·694	17·4
146 107	1000·677	17·45
147 108	10006·8	17·35
148 109	10006·8	17·35

These experiments were carried out at the Cavendish Laboratory, by the secretary and Mr. W. Wilson, of St. John's College.

At the request of M. Mascart, the secretary compared with the legal ohms of the Association the mercury copies of a legal ohm constructed by Mr. J. R. Benoit, of Paris. The detailed account of their experiments was laid before the Physical Society. The values found are given below :—

No. of tube.	Value found by Mr. J. R. Benoit.	Value found by R. T. G.	Diff.
37	1·00045	·99990	·00055
38	1·00066	1·00011	·00055
39	·99954	·99917	·00037
Mean	1·00022	·99972	·00049

The work of testing resistance coils has been continued, and a table of the values found for the various coils examined is given :—

No. of coil.	R. in B. A. units.	Temp.
Elliott, No. 122	10·0163	19·8
(B.A. No.)	10·0017	15·2
	9·9885	10·5
Elliott, No. 58	9·9834	14·05

Legal Ohms.

No. of Coil.	R. in Legal Ohms.	T.
In 150	·99895	11·7
,, 151	·99974	13·9
Elliott 149 (B.A. No.)152	·99912	12·5
Elliott 136 (B.A. No.)153	·99977	12·4
(B.A. No.)154	1·00032	17·3

The Committee hope that arrangements may be made for issuing standards of electromotive force and constructing standards of capacity. In conclusion they would ask to be reappointed, with the addition of the names of Prof. J. J. Thomson and Mr. W. W. Shaw, with a renewal of the unexpended grant of £50.

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THE ELECTRICIAN.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE CONFERENCE AND THE CABLE COMPANIES.

The work of the Berlin Telegraph Conference is none the less creditable for falling short of its original programme. That programme, as we predicted, and as the President had to confess, was too radical, or, as he preferred to call it, too premature, to be carried out in its entirety. But the bases of uniformity and simplicity of tariffs throughout the European systems have been established in an unexceptionable manner, and with probable advantage to all the nations concerned. As regards the Cable Companies the same cannot be said. The aims of the Conference, or, at all events, those of its presiding genius, were antagonistic to the interests of non-national telegraph property, and have been abandoned only after a struggle, which, however, did have the wholesome effect of extorting an admission that no fault could be found with the cable proprietors in respect to the liberal concessions they had voluntarily made to promote the welfare of international telegraphy.

These declarations of Herr von Stephan are a sufficient answer to the wild and conflicting accounts that have appeared in the English newspapers during the sitting of the Conference. In reality, its actual business was known only to those engaged upon it; and only such of its intentions were made known to English correspondents at Berlin as happened to suit the objects of the leading spirits among the delegates. So judiciously was this privilege worked in at least one quarter that a favoured English newspaper virtually became a semi-official organ of the party most opposed to English interests. Its lead was naturally followed by other organs even more ill-informed, with the singular result that during the concluding days of the Conference there was an unanimity of opinion—if an echo of an echo can be called an opinion—which would have been marvellous had it been less obviously inspired and less maliciously directed against one particular Company.

How unsafe it was to predict what would happen, or to describe what was supposed to have been actually settled, was curiously illustrated by the dramatic incident of last week, when the representative of Egypt surprised almost everybody by threatening to place Egyptian telegraphs within the European *régime* unless certain demands upon the Eastern Telegraph Company were complied with. The effect of yielding to this threat would have been to inflict a heavy fine upon that Company, which is not, and cannot be included in the Union, but whose system is interlaced with that of the Khedive's dominions. This catastrophe was to some extent averted; but solely by action on the part of the Company, the Conference itself apparently being quite willing to be made the instrument for victimising the owners of any telegraph property not enjoying the privilege of being governmental. The concessions extorted from the Company go exclusively into the pocket of the Egyptian treasury, the public benefiting by them not at all. Yet in reference to this subject the same English journal which a few months ago was loudest in its praises of the self-sacrificing patriotism of the Eastern Telegraph Company suddenly became foremost in condemning its selfishness and greed!

This Egyptian episode is of a piece with the whole proceedings of the Conference, so far as they affected the owners of Submarine Cables. We are ready to admit that the position of affairs is anomalous. Inland Telegraphs are everywhere the property of the nation, which has either erected or purchased them, whereas the oceanic systems are the property of private individuals. Moreover, the action of the European Telegraph Union has uniformly tended to internationalise the land lines, though leaving to each country undisturbed ownership and responsibility. The cable system alone remains outside this controlling tendency; and having no Government to father it, nor any recognised position in the Union, it has become the object of much jealousy and pressure, which, if not steadfastly opposed, would place it under the control of the national delegates, while neither separately nor conjointly would the nations they represent accept any responsibility for its financial welfare.

The anomaly, however, is the result of circumstances, and is, in reality, highly creditable to those who have created it To the courage, enterprise, and skill, chiefly of Englishmen, the world owes its magnificent trans-oceanic telegraph system. The nations did nothing to create it and hardly anything to encourage it. Private individuals have taken all the risks, sustained all the losses, and notoriously, with few exceptions, have reaped but small profits. That their property is not under the control of the Telegraph Union is no fault of the Companies; yet because they cannot afford to share its enthusiasm for "democratic rates," they are reproached with maintaining an anomaly opposed to the interests of a Cosmopolitan commonwealth. The bulk of the cables belong to British subjects; and with just as much reason the same accusation might be hurled against the British navy.

We do not complain of any legitimate efforts to lower the telegraph tariffs of the world; it is a natural tendency to which Cable Companies not less than national Governments have conformed. But to intimidate outsiders, or to require them to make heavy pecuniary sacrifices to please the European Governments, is conduct which any single nation would be ashamed of, and which only escapes absurdity by being the joint action

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of many. Acceptance of the Egyptian proposal would have been an act of this kind; and a statement has got abroad that the Companies were threatened with opposition Cables if the Union's terms were not agreed to. The threat is too silly to have been made in earnest at all. When nations are of one mind as to this, they will probably be of one mind also in seeing that if they must have Cables of their own they can have them cheaper by buying those already laid rather than by laying fresh ones to compete on terms that would be ruinous to all. A combination of Governments to lay and maintain Submarine Cables which any one of the maritime parties to the bargain would instantly destroy in time of war may be expected when invading armies agree to respect the enemies' land wires and railroads.

It does not surprise us, however, that a suggestion for an international cable proprietorship has been put forward at this juncture. If it serves no better purpose it will push the pretensions of the Union to their logical outcome. Perhaps the delegates never thought of this; being only heads of departments, and not national representatives in any political sense, they may now perceive that there are political consequences bound up with their proceedings which they are quite incompetent to deal with. The English delegates at all events ought to see this. There are far worse things than anomalies, and one of them would be for England some day to discover that she to whom nine-tenths of the world's cable property belongs, in whose interests and for whose safety chiefly it has been created, had pledged it for the temporary friendship of nations who would have the strongest temptation to break their bargain at a pinch, and the very strongest motives for keeping her to hers. We see in the action of the late Conference certain indications of a jealous and hostile attitude towards England's pre-eminent position as mistress of the seas, beneath as well as above; and it behoves the English Government, but primarily the English Cable Companies, to look to their own safety without reference to the benevolent but selfish aims of the Continental nations. As to the tariffs, they can and will be cheapened when cheapening them will proportionately increase the receipts without increasing the expenditure. The nonsense talked about shilling telegrams to Australia, because there are to be sixpenny telegrams in England, may be dismissed until the day when *The Times* newspaper, for example, magnanimously accepts advertisements for nothing because it can earn "seven per cent." without charging for them; or when the P. and O. Company will take passengers to India for twopence because there are penny steamboats on the Thames.

CORRESPONDENCE.

ELECTROSTATIC CAPACITY OF OVERGROUND WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the late Prof. F. Jenkin's "Electricity and Magnetism" (p. 332, first edition) is a formula for the capacity of an overhead wire. Owing to the remark there made that experiment gave results nearly double as great as the formula which was attributed by him to induction between the wires and the posts and insulating supports, and thinking that the presence of neighbouring wires should have a marked influence in increasing the capacity, owing to the neighbouring wires being earthed, I verified this by working out the theoretical formulæ for the capacities (self and mutual) of overground parallel wires, and applying them numerically in a special case. (Paper in some back volume of *Journal* of S. T. E. and E. Cannot say which, as my separate copy of the paper has no date or reference, a curious omission I observe in all the S. T. E. and E.'s separate copies.) With one additional parallel wire the increase of the capacity of the first was 11 per cent.; with three additionals it was 24 per cent. As to further increase by more wires, it would not be *very* great, as they practically would be much further away. As a guess, it might run up to 50 or 60 per cent., with a large number of wires, but of course it would depend materially upon their mutual distances and height above the ground.

The recent measurements of capacities of wires in the North of England supply some definite information. Taking the case of a wire 20ft. above the ground of diameter ·08in., the calculated capacity, supposing there to be no other wires (nor trees, &c.), is ·0095 mcf. per mile. The average result observed is given in Mr. Preece's paper (p. 348, last number of *Electrician*) as ·0120 with the other wires insulated, and ·0142 when earthed. And for the iron wire, ·171in. diameter, supposed 20ft. above the ground, the similar three results are ·0103, ·0131, and ·0169. I take $v = 30^{10}$ instead of the 2880^{8} conv. used in the paper referred to.

In both cases we may observe that the experimental result with wires insulated is about midway between the calculated result and the experimental result with wires earthed, so that it would appear that the influence of surrounding objects (other than neighbouring wires earthed) in increasing the capacity was about equal to that of the neighbouring wires themselves. This might, of course, be true in some particular case, but we cannot safely conclude it from the above, on account of leakage, as may be seen thus. If the wire experimented on were perfectly insulated from earth through the poles, whilst the other wires (though insulated at the ends) were so very badly insulated at the poles that they could be considered as connected to earth, it is clear that a measurement of capacity of the first wire would give the highest result. And this would be true with fair insulation, if the total charge could be observed. But when the observation is made by throw of needle, only a part of the charge is observed, the remainder (due to the leakage of the neighbouring wires) going in slowly, or coming out slowly when discharge is taken. In any case, however, the effect of the imperfect insulation of the neighbouring wires is to make the apparent capacity greater, and so reduce the difference between the capacity with wires insulated and to earth. Thus bettering the insulation would shift the middle results above towards the lower.

How far this operates might be experimentally determined by charging the first wire with the others insulated, then waiting a little, and observing the extra charge produced by suddenly earthing the other wires. If the insulation be bad, the extra charge will be *nil*; if first-rate, it might nearly amount to the full difference.—Yours, &c.,

OLIVER HEAVISIDE.

ON DISTRIBUTION OF ELECTRICITY BY SECONDARY GENERATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the *Philosophical Magazine* for September, Dr. J. Hopkinson has drawn attention to a possible source of danger in connection with secondary generators.

This communication was reprinted in your issue of the 4th September, and could not fail to have attracted the attention of your numerous readers.

In the International Inventions Exhibition the Edison and Swan United Electric Light Company are exhibiting at their stall, in the East Arcade, 200 Edison-Swan incandescent lamps, supplied from two of the annular induction transformers of MM. Zipernowski-Deri, constructed by M. Ganz and Co., of Buda Pesth. The exciting dynamo which supplies the primary current is in the American Court, at a distance of about 800ft., and the primary current is conveyed by a No. 10 B.W.G. copper wire to the transformers. Dr. Hopkinson has pointed out that as an induction coil also acts as a condenser, it is possible, if its electrostatic capacity considered as a condenser is sufficient, that a discharge current could be obtained from the

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secondary circuit sufficient to be dangerous if passed through the human body. As soon as Dr. Hopkinson's communication appeared it occurred to me that this source of danger could be removed by connecting one wire of the secondary circuit to earth, and that in this case, even if the secondary generators have electrostatic capacity other than a very small quantity, this device will effectually prevent electrostatic accumulation of electricity in the secondary circuit, although a certain small loss of energy will result from the charging and discharging of the secondary generator by electrostatic induction.

At the Exhibition, accordingly, the experiment was immediately tried by taking a wire from one side of the secondary wire and connecting it to a good earth. This does not interfere in the least with the steadiness of the lighting. I mentioned this safeguard against this possible electrostatic accumulation to Dr. Hopkinson, and I have his permission to state that he considers it a complete insurance against any such danger as that to which he has called attention. It is satisfactory to find that so simple a means removes a doubt that might otherwise have arisen in the public use of secondary generators in connection with electric lighting.—Yours, &c.,

J. A. FLEMING,
Electrician to the Edison and Swan United Electric Light Company(Limited).

57, Holborn-viaduct.

ELECTRICAL CONDITION OF THE HUMAN BODY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In Dr. Stone's very interesting paper, published in your last issue, the human body is said to closely resemble a faulty submarine cable. As this is likely to give rise to some misapprehension on the subject, I should like to ask Dr. Stone for a clearer expression of his meaning. A submarine cable may be faulty in several ways, and it is only to one of these conditions, *i.e.*, an abnormally low insulation resistance, that the human body bears any resemblance. The currents set up by the body itself cannot be compared with the polarisation currents due, for instance, to a complete rupture of the cable and consequent exposure of the conductor; but the phenomena attending the electrification of the body present a very close affinity with those which may be observed when a long section of insulated cable having an appreciable and variable earth current is similarly treated. As regards the comparison made between the human body and a leaky condenser, I am glad to meet with a corroboration of my own views. I may mention that the results of some of my own experiments, using 20 volts, gave the capacities of three individuals as 3·0, 2·9, and 5·4 micros.; the mean effective insulation resistance of the latter, calculated by fall of potential, being 9 megs. In reference to the process of electrification of the body, in view of its alleged similarity to a faulty cable, the following figures may be of interest. It will be observed that the gradual fall in the deflections, and corresponding increase in the resistance indicated by it are, in the case of a submarine cable, by no means compatible with a faulty condition.

Subject A.—Z to right hand, standing 6ft. from galvanometer. Shunt 1 ohm. Fifteen Leclanché cells.

45″ ..... 398 to 403
1′ ..... 393 „ 410 = 401 = 7086 ohms.
2′ ..... 390 „ 421
3′ ..... 375 „ 412
4′ ..... 385 „ 353
5′ ..... 358 „ 343 = 350 = 8571 ohms.

Discharge after 1 min. E. = 5, neg. steady.

Subject B.—Same conditions.

Personal current = 1 division. Shunt 1 ohm.

1′ ..... 535 to 511
2′ ..... — 435
3′ ..... 438 „ 448
4′ ..... — 400
5′ ..... 355 „ 358

Discharge after 1 min. E. = 4, neg. steady.

Subject A.—Same conditions.

1 min. = 472 divs.

Discharge after 1 min. E. = 5, neg. steady.

Subject B.—1 min. not taken.

1′ 15″ ..... — 570 = 5272 ohms.
2′ ..... 510 to 520
3′ ..... 520 „ 600
4′ ..... 560 „ 480
5′ ..... 495 „ 450 = 6377 ohms.

Discharge after 1 min. E. = 6, neg. steady.

The slightest movement *or difference of pressure* had a considerable effect upon the readings. Probably the nature of the contact was altered.

These figures represent the actual resistance of the body from hand to hand in its *normal* condition. The body discharged itself readily to E, but if insulated had an E of 9 megs., as we have seen in, at all events, one case. Under electrification it behaved exactly as a submarine cable of low insulation resistance, and with, as I have said, a variable earth current.—Yours, &c., A. E. BAINES.

THE LIFE OF INCANDESCENT LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: "Carbon" has exposed the fallacy in Mr. Grundy's figures by means of examples evolved from his inner consciousness; he might, however, have taken an impressive example from Mr. Grundy's own tables. Thus we find on referring to the statement published in your issue of 4th inst., page 315, that on the "New All Day Circuit" 28 lamps have run for 480·5 hours with only one natural death, and as this occurred on the first day, we may fairly take a fresh start, and say the remaining 26 lamps (one having been accidentally broken) have been burning 456·5 hours *without a single death.* Using Mr. Grundy's formula we have—

$$\text{average life of lamps} = \frac{456{\cdot}5}{0} = \text{infinity.}$$

We believe that a few million years hence—

"The cloud capp'd towers, the gorgeous palaces,
"The solemn temples, the great globe itself,
"Yea, all which it inherit, shall dissolve!"

Yet these twenty-six immortals shall surely illumine chaos through the Æons, a glorious monument to the nineteenth century in general, and to the skill of the Edison-Swan Company in particular.

In conclusion, let me urge Mr. Grundy to lay to heart the old "saw" (slightly altered), "Don't reckon on the life of your lamps before they are dead."—Yours, &c., S. E.

SIR LYON PLAYFAIR'S ADDRESS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As a constant reader of your valuable journal I venture to offer you the following remarks, having reference to Sir Lyon Playfair's Presidential Address at the British Association meeting, as reported in your issue of the 11th inst.

After careful perusal it occurs to me that a point upon which the author might, perhaps, have been expected to enlarge has only very shortly been touched upon.

The subject of the address, as stated by the President, was "The Relations of Science to the Public Weal," and a large portion of it was occupied in considering the present attitude of the State with regard to scientific education.

Throughout the address, however, very little mention is made of those wonderful scientific discoveries by which such blessings and benefits have been conferred upon mankind, and which, I think, might with advantage have occupied a prominent place in the address, as serving to strengthen the cause for which the author was pleading.

The State apparently not being yet alive to the importance of scientific education, it is very necessary to lose no opportunity of strengthening its claim where possible, nor to allow it to be forgotten how much we are indebted to science for the present state of perfection to which we have arrived.

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It cannot, I suppose, be expected that the nation's money will be advanced in furtherance of scientific education until it is made aware of what it is indebted to science for and what it may expect from her in the future.

As to the first, a glance around will furnish an ample answer.

Lord Macaulay has thus enumerated some of the services which have been rendered by science in promoting human welfare :—"It has lengthened life; it has mitigated pain; it has extinguished diseases; it has increased the fertility of the soil; it has given new securities to the mariner; it has furnished new arms to the warrior; it has spanned great rivers and estuaries with bridges of form unknown to our fathers; it has guided the thunderbolt innocuously from heaven to earth; it has lighted up the night with the splendour of the day; it has extended the range of the human vision; it has multiplied the power of the human muscles; it has accelerated motion; it has annihilated distance; it has facilitated intercourse, correspondence, all friendly offices, all despatch of business; it has enabled man to descend to the depths of the sea, to soar into the air, to penetrate securely into the noxious recesses of the earth, to traverse the land in cars which whirl along without horses, to cross the ocean in ships which run ten knots an hour against the wind."

With regard to the future progress of science, a learned professor has stated as his opinion that whereas the highest points in Literature and Art had been attained, the future developments of science would mark the continuous progress of knowledge in the world.*

Another subject of great importance which is mentioned in the address is the present system of examinations, and which, without confining the subject within the limits of Sir Lyon Playfair's remarks, may well claim attention at the present time, as in a few weeks the winter term of study will have commenced, and preparations for examinations next May will have begun.

Opinions have, I think, been expressed lately that the present mode of carrying out examinations is open to improvement, and there is much to commend itself in the system adopted by the late Prof. F. Jenkin, one argument in its favour being that it would very rarely happen that a student, when left to himself, would trust wholly to his memory, and at least would always have hand-books ready for reference and confirmation of his conclusions. In addition to this, the use of note-books at examinations would tend to urge a student to keep his notes in good order, a point to which I have found teachers always give great prominence, but which in many cases is not now done.

Lastly, objection will perhaps be raised (as, indeed, it is by *The Engineer*) to Sir Lyon Playfair's advice "to advance science for its own sake, and not for its applications;" but I think that in this must consist the argument in favour of the study of science for a large number of persons, as it cannot be expected that each individual student will, as the result of his studies, be enabled to confer a new blessing on mankind. One result, however, of the study of science (and which, I think, alone justifies Sir Lyon Playfair's views) is that the mind becomes occupied with high and worthy thoughts, to the exclusion of others, which materially tend to raise the whole life to a higher standard; and especially is this the case, I think, where the science studied proves interesting, as with that science to which your journal is devoted, and the other sciences which of necessity follow in its train.—Yours, &c.,

Westminster, Sept. 14, 1885. A. NEWMAN.

* Prof. Tomlinson at the Birkbeck Institution, 3rd October, 1883.

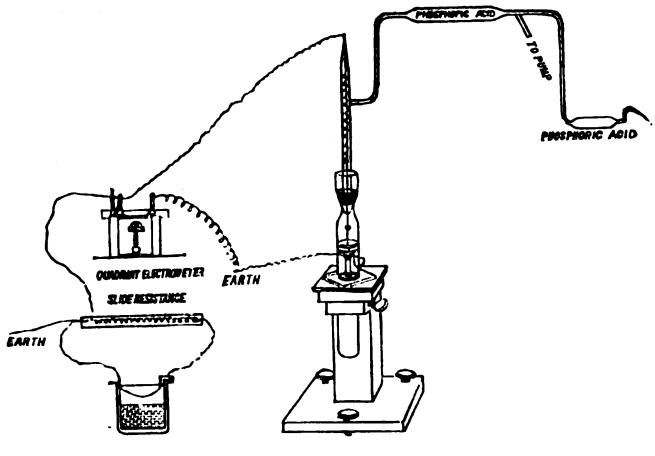
AN ELECTRIC CRANE.—An electric crane is in use in one of the foundries of M. Farcot, at St. Ouen. The generator is situated at a distance of 100 metres, the receptor being set up in the leverage apparatus, on the axis of which a force equal to 4 horse-power is developed. Whereas the crane was formerly worked by ten men, it is now attended to by one. The new crane has resulted in a considerable saving of hand labour.

ON CONTACT ELECTRICITY IN COMMON AIR, VACUUM, AND DIFFERENT GASES.*

BY. J. T. BOTTOMLEY, M.A., F.R.S.E.

The discussion at the British Association meeting at Montreal last year on the seat of electromotive force in the voltaic cell, the paper of Prof. O. Lodge which resulted from that discussion, and the subsequent discussion at the Society of Telegraph Engineers, must have brought forcibly before the minds of those interested in the subject the extremely unsatisfactory state of our experimental knowledge on some of the fundamental questions relating to contact electricity. Foremost among these, perhaps, is the question of the behaviour of various metals as to Volta contact effect in air and vacuum, and in gases different from common air. I have undertaken a series of experiments on this subject, and have already obtained some definite results, although the experiments which I have made up to this time are only to be considered as preliminary to a fuller inquiry.

The apparatus which I am using is shown in the diagram. The lower of the two plates to be experimented on is supported in the vacuum chamber by a small stand with a glass pillar; and the electrode from this plate passes through the side of the chamber, hermetically sealed into it. The upper plate is hung from the top by a long platinum spiral, the upper end of which is also hermetically sealed into the glass. To the lower end of the spiral is attached a long hook which carries the lower plate, and at the junction of the spiral with this hook there is a small globe of soft iron. It is by means of this small soft iron globe and a magnet applied outside the tube that the upper plate is lifted from the lower plate. The nature of the vacuum chamber and its connection to the pump will be readily understood from the diagram. The final adjustment of distance between the two plates when at their nearest is done at the top of the tube, by heating it and drawing out the glass carefully, or else letting it fall in, till the adjustment is satisfactorily made. The branch tube on the right hand side of the diagram, which is shown sealed off, is used for supplying gases to the apparatus. A small part only of the drying and purifying apparatus is shown in the diagram.



For determining the value of the Volta contact effect, I have used the quadrant electrometer and the compensation method of Sir William Thomson. The Daniell cell and slide resistance and the connections are shown in the figure. The method is so well known that it need not be described here. It was described in *Nature*, April 14, 1881, and has also been described in the paper of Prof. O. Lodge, which was printed in the British Association *Reports* and elsewhere.

The plates which I have used are zinc and copper discs a little larger than a shilling. Testing them first with full air pressure I found that the Volta contact difference was rather over 0·74 volt; which is as nearly as possible what has been found by previous experimenters, and by myself experimenting a few weeks ago with Sir William Thomson's old contact apparatus.

* Abstract of Paper read before the British Association at Aberdeen.

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The air was then very carefully exhausted; the exhaustion being maintained for two days, and finally made exceedingly good with 2½ hours' work at the pump, just before testing. The pressure during the testing was not greater, and was probably much less than $\frac{1}{5}\frac{1}{2}\frac{1}{3}$ mm. of mercury, or 2·5 **M**. (2½ millionths of an atmosphere). The electrical test was then applied, and the value of the Volta contact effect was found to be *exactly the same as before*, a little over 0·74 volt. The final test, however, consisted in allowing the air to come back into the apparatus, and then testing electrically. This was done by breaking the point of the sealed tube to the right of the diagram, and as the air entered the electrometer test was rapidly applied. So far as the sensitiveness of the testing apparatus goes, there was absolutely no change in the Volta contact difference.

My experiments, therefore, are absolutely contradictory, so far as they have gone, to those of Dr. W. Von Zahn, quoted by Prof. Lodge, who experimented in a high vacuum, and found the Volta effect to be diminished, and to be represented by a potential difference of only half a Daniell.

I have also experimented on hydrogen and oxygen gases in this apparatus in a way precisely similar to that described above. The chamber was very carefully exhausted, and the Volta contact effect tested with the electrometer. Hydrogen was then admitted, and while it was entering, which it was forced to do slowly, the electrical testing was repeated several times.

A second and a third exhaustion were made, and hydrogen admitted a second and a third time. The same was subsequently done with oxygen, except that it was, of course, sufficient to admit the oxygen a single time. The result of my investigation, so far as it has gone, is that the Volta contact effect, so long as the plates are clean, is exactly the same in common air, in a high vacuum, in hydrogen at small and great pressure, and in oxygen. My apparatus and the method of working during these experiments was so sensitive that I should certainly have detected a variation of one per cent. in the value of the Volta contact effect, if such a variation had presented itself. To do away with all question as to the dependence of the Volta effect on "ancient air sheets," I propose to modify my apparatus by making the vacuum chamber much longer, and finally of combustion tubing. I shall then apply great heat to the plates while they are contained in a vacuum as high as I can command. If, then, there be any ancient air sheets existing, they must either be driven off or else absorbed into the plates. If any gas be driven off it will be removed by the pump. The plates will then be tested when they have perfectly cooled, and the value of the contact difference determined. That being done, the atmospheric air or some other gas will be admitted, and the contact difference will be again determined. The effect of the pressure of the atmosphere or other gas will, I think we may safely suppose, be thus ascertained. In conclusion, I have to express my indebtedness to Mr. J. Rennie, assistant to the Professor of Natural Philosophy in the University of Glasgow, for most valuable assistance during my investigation.

COOLING OF WIRES IN AIR AND VACUUM.*

BY J. T. BOTTOMLEY, M.A., F.R.S.E.

This paper gives a brief account of recent experiments on radiation of heat from the surface of metallic wires in air and in vacuum. A preliminary paper on this subject was communicated to the British Association at its meeting last year. Since that time the arrangements for experimenting have been greatly improved, and further results have been obtained. The object is to determine, in absolute measure, the loss of heat from the surface of small wires of various materials, both uncovered and when covered with various coatings, the wires being surrounded with different gases at various pressures down to the very lowest.

The chief experimenters on this subject in recent times have been Kundt and Warburg and Mr. Crookes. My method of experimenting, which is very different from that of other experimenters, consists in passing a current of known strength through the wire under examination, and determining the increase in the resistance of the wire due to heating of the current, when the wire has assumed a permanent temperature with the given current passing through it. When temperature of the wire has become constant, the heat generated by the current (which can be calculated in absolute measure) must be equal to that emitted at the surface of the wire, plus that lost at the ends of the wire. The temperature of the wire at the moment is also ascertained from its resistance (as was done by Siemens in his experiments in resistance of platinum wire at different temperatures, *Proc.* R.S. Vol. XIX., p. 443), and the emissivity of the surface of the wire can thus be determined in absolute measure.

My recent experiments have been directed to the determination of emissivities in very high vacuums. Using a Sprengel pump with five full tubes and a M'Leod gauge of improved construction due to Mr. C. H. Gimingham, I have obtained and measured a vacuum with air pressure as low as $\frac{1}{3}\frac{1}{0}$ **M**. (one thirty-millionth of an atmosphere).

The wire with which I am experimenting at present is a platinum wire half a metre long and 0·04 centimetre in diameter. It is contained in a glass tube about 0·6 centimetre in internal diameter.

A table of emissivities for metallic surfaces has not yet been completed, but one result obtained with high vacuum may be quoted. On passing a current of 1·18 ampere through this wire with full air pressure, the permanent temperature attained by the wire was 75°C., the temperature of the room at the time being 15°2·C. On exhausting down to $\frac{1}{1}\frac{1}{5}$ **M**.$\left(\frac{1}{19\times10^6}\text{ atmo.}\right)$, and passing the same current, the wire became heated to a good red heat.

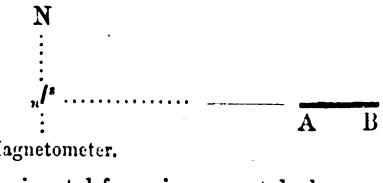
ON A SPECIMEN OF ALMOST UNMAGNETISABLE STEEL.*

BY J. T. BOTTOMLEY, M.A., F.R.S.E.

The author has examined a specimen of steel presented to Sir William Thomson by Mr. R. R. Eadon, of the firm of Moses Eadon and Sons, Sheffield. This steel is made under Hadfield's patent, and the specimen contains 15 per cent. of manganese. One side of the bar has been polished, and shows that the steel is capable of taking a very high finish. The present specimen has probably a tensile strength of 45 tons to the square inch.

To test it magnetically the bar was first "touched" with steel magnets; and such preliminary tests seemed to show that the magnets had not the slightest effect upon it. It was then placed between the poles of a powerful Rhumkorf electromagnet, which was excited by 40 large tray Daniells arranged in fours for quantity and ten in series; and the process for magnetising which is always used in the Glasgow University Laboratory, and which is very satisfactory, was proceeded with. It was very astonishing to find the bar of steel absolutely unaffected by the electro-magnet so far as could be perceived by the hand.

After magnetisation the bar was tested carefully by the magnetometer method, which consists in placing the magnet to be tested at a known distance from a very short suspended magnet in a known position, the suspended needle being in a



Magnetometer.

place where the horizontal force is accurately known, and by the deflection of the magnetometer comparing the force of the bar with that of the earth.

With the bar to the east or west of the magnetometer, the

* Abstract of Paper read before the British Association at Aberdeen.

* Abstract of Paper read before the British Association at Aberdeen.

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formula for calculating the magnetic moment of the bar is as follows :—

$$\mu = H \frac{2d}{(d^2 - l^2)^2} \tan \theta.$$

Where μ is the magnetic moment,
H horizontal force,
d distance of centre of bar from centre of magnetometer,
$2l$ effective length of bar,
θ angle of deflection,

a mirror magnetometer being used, and the deflection being very small, $\tan \theta = \theta$, and θ is equal to half the number of scale divisions of the deflection divided by the distance in scale divisions of the scale from the magnetometer.

In the present instance the effective length of the bar has been estimated at 10 centims., the real length over all being 14·29 centims. The value of H is very accurately known at a certain place in the Glasgow University Laboratory. The experiment on the bar gave for the magnetic moment

$$\mu = 2{\cdot}55.$$

The weight of the magnet is 192·09 grammes. Hence the magnetisation per gramme of this specimen of steel is

$$\frac{2{\cdot}55}{192{\cdot}09} = 0{\cdot}013 \text{ C.G.S.}$$

per gramme.

To compare this with other specimens of steel, we find in many specimens that magnetisation of 40, 50, or even 60 C.G.S. per gramme can be obtained. In some specimens as much as 90 or even 100 C.G.S. per gramme has been obtained.

P.S.—The author has been informed that Dr. Hopkinson has already experimented on steel containing manganese, and has obtained similar results. He has not, however, seen Dr. Hopkinson's figures, and is unable to compare his own results with them.

DOMESTIC ELECTRIC LIGHTING.*

BY W. H. PREECE, F.R.S., ELECTRICIAN G.P.O.

After referring to the full details of the lighting installation of his house in Wimbledon, given to the Section at the meeting at Montreal, Mr. Preece spoke generally of the experiences he had gained during the past twelve months. The secondary batteries upon which he had mainly relied exceeded his expectations in the services they rendered. They returned 70 per cent. of the energy put into them without any apparent diminution whatever in their E.M.F. They showed no signs of deterioration, and gave no trouble whatever. He used his gas engine for charging only two days a week. He had experienced no fault with the wiring of his house. He had used only the very best materials, and had attended personally to the insulation of the system. It was periodically tested and found to be good. He condemned, in severe terms, the cheap and nasty wire which was so frequently and ignorantly used, and feared that the prejudice against the electric light would increase when failures from this cause arose. None but the very best materials should be used, and the joints should be seen to by experts. He had devoted considerable attention to the problem of distributing light, and had succeeded so far that while his rooms were beautifully illuminated the eye was not irritated by regarding a bright source of light. The lamp he used was a 50-volt 10 candle-power glow lamp, and it was, as a rule, so fixed that the eye never saw it. He had arrived at the use of these lamps after careful consideration and many trials of other lamps. They secured greater safety in the leads, and involved less capital in batteries through the use of low E.M.F.

Mr. Preece went on to say that he ran his lamps at an E.M.F. about 2 per cent. less than the normal E.M.F. He did this to secure long life to his lamps. The breakage had been very small. The E.M.F. and current which will give a lamp a normal life of 1,000 hours and a certain candle-power should be determined by every maker. The sixth power of the current will give the candle-power and the twenty-fifth power the life with any other current. The great advantage of batteries is that the proper current once determined can never be exceeded, and thus efficiency is ensured. If lamps are run too low there is a waste of power, if too high there is waste of lamps. We are, Mr. Preece thinks, now gradually acquiring a thorough knowledge of the number of watts which should be expended in each lamp to secure the maximum economic efficiency.

He had introduced into the charging lead, and into the discharging lead a Ferranti meter, so that he was able to record exactly the quantity of electricity passed through the batteries and that passed through the lamps. This beautiful meter is based on Ampère's laws, which determine the attraction and repulsion of currents.

A small phosphor-bronze vane is immersed in a bath of mercury, through which the current flows radially, fixed in a magnetic field. The mercury rotates and carries with it the vane. The rate of rotation varies directly with the strength of current, and the number of rotations are recorded by a counter, which can be read off directly. So far, he was perfectly satisfied with its performance.

As regards expense, excepting the first cost, Mr. Preece did not find much addition to his expenditure for illumination. His electric light was costing him about £50 a year for gas, wages, oil, and lamps. It was the cheapest luxury he indulged in. The greatest advantages were the comfort and cheerfulness it engendered, and as cheerfulness was the main element of health, he thought that the electric light would prove a serious rival to the doctor. There was no one who valued health and comfort who should neglect to apply the electric light to his home when it was brought, as it has been, by the success of the secondary batteries, within his means.

It was said that he, as an expert, could make things go which would fail in ordinary hands; but he mentioned several cases where coachmen, butlers, gardeners, and grooms had been found perfectly competent and intelligent enough to attend to everything.

* A Paper read before the British Association at Aberdeen

ON THE THERMODYNAMIC EFFICIENCY OF THE THERMOPILE.*

BY LORD RAYLEIGH, F.R.S.

During the last few years the thoughts of many electricians have turned to the question of the possibility of replacing the dynamo by some development of the thermopile; and it is, I believe, pretty generally recognised that the difficulty in the way is the too free passage of heat by ordinary conduction from the hot to the cold junction. The matter may perhaps be placed in a clearer light by an actual calculation, accompanied by a rough numerical estimate applicable to the case of German silver and iron.

If t, t_0 denote the temperatures of the hot and cold junctions respectively, e the electromotive force per degree centigrade, the whole electromotive force for n pairs in series will be represented approximately by

$$ne(t - t_0).$$

The magnitude of the current (C) is found by dividing this by the sum of the internal and external resistances ($R_0 + R$); and the useful work done externally per second is RC^2. It reaches a maximum when the external resistance is equal to the internal; and its amount is then

$$\frac{n^2 e^2 (t - t_0)^2}{4R_0}.$$

The value of the internal resistance R_0 depends upon the dimensions of specific resistances of the bars. Denoting the latter quantities by r_1, r_2, and taking σ_1, σ_2 to represent the areas of section, the common length being l, we have

$$R_0 = nl\left(\frac{r_1}{\sigma_1} + \frac{r_2}{\sigma_2}\right);$$

* Paper read at the Aberdeen Meeting of the British Association.

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so that the external work per second is

$$\frac{ne^2(t-t_0)^2}{4l\left(\frac{r_1}{\sigma_1}+\frac{r_2}{\sigma_2}\right)}.$$

We will now compare this with the work dissipated by ordinary conduction of heat along the bars.

If Q be the amount of heat conducted by the n pairs, r'_1, r'_2 the *thermal* resistances, then

$$Q = n\left(\frac{\sigma_1}{r'_1 l}+\frac{\sigma_2}{r'_2 l}\right)(t-t_0).$$

The fraction of this heat, supplied at temperature t, which might be converted into work by a perfect engine working between the absolute temperature, t and t_0, is $(t-t_0)/t$; so that the work dissipated per second is

$$\frac{nJ(t-t_0)^2}{tl}\left(\frac{\sigma_1}{r'l}+\frac{\sigma_2}{r'l}\right),$$

where J denotes the mechanical equivalent of heat.

The ratio of this to the useful work is

$$\frac{4J}{te^2}\left(\frac{r_1}{\sigma_1}+\frac{r_2}{\sigma_2}\right)\left(\frac{\sigma_1}{r'_1}+\frac{\sigma_2}{r'_2}\right),$$

independent of $(t-t_0)$, of n, and of l. It is further evident that the ratio in question does not depend upon the absolute values of the sections, or of the electrical and thermal resistances, but only upon the *ratios* of these quantities. Thus the *efficiency* of the thermopile is independent of the absolute dimensions of the bars, and even of the difference of temperatures at the junctions. The *power* is increased by diminishing the length and increasing the sections to a limit not indicated by these expressions (in which the terminal temperatures are regarded as given), and probably determined in practice by the necessity of conveying the heat to the scene of action.

The resistances being given, the ratio of sections σ_2/σ_1 is to be determined so as to make our ratio a minimum. This happens when

$$\left(\frac{\sigma_2}{\sigma_1}\right)^2 = \frac{r_2 r'_2}{r_1 r'_1};$$

and thus we get

$$\frac{4J}{te_2}\left(\sqrt{\frac{r_1}{r'_1}}+\sqrt{\frac{r_2}{r'_2}}\right)^2.$$

To turn this into numbers for the case of German silver and iron, we have the following approximate numbers in C.G.S. measure* :—

$$r_1 = 2{\cdot}0\times10^4, \qquad r'_1 = 1{\cdot}0\times10^1$$
$$r_2 = 1{\cdot}0\times10^4, \qquad r'_2 = 5{\cdot}0\times10^0$$
$$e = 3{\cdot}0\times10^3.$$

The value of J is $4{\cdot}2\times10^7$, and for t we will assume 500 (absolute measure). The use of these gives, as the ratio of the work that would be obtained by a perfect engine from the conducted heat to that actually obtained from the thermo-electric force, the number 300; from which we may conclude that the steam engine and dynamo are not likely to be superseded by a German silver and iron thermopile, even though considerable allowance be made for the admitted roughness of the numerical estimate.

As regards other materials, it is interesting to note that the ratio contains as divisor the *square* of the electromotive force per degree.

* Everett's "Units and Physical Constants," Landolt's *Tabellen*.

ELECTRIC LIGHT SWITCHES.

We illustrate below two forms of switches lately designed by Mr. N. G. Thompson. The large switch, Figs. 1 and 2, has been constructed with a view to balancing the pressure generally found necessary to form good contact, and to compensate for wear and tear. In the majority of switches now made for heavy currents the requisite pressure is given by means of a spring acting on the spindle, which throws the wear and strain on that part. This is obviated in Mr. Thompson's switch by making the contact plates in the form of a cylinder cut into segments, a a a, and secured by a flange to the wood base b. Two plugs, c c, are fitted loosely into the cross tube d, and are forced out against the segments by means of the spiral spring e; a strip of metal in the form of a bow, f, is also secured to the plugs c c, and any convenient handle is attached to the tube d. It will thus be seen that the pressure on the segments is completely balanced, without in any way affecting the spindle and handle to which the tube is fixed. The bow-shaped piece of metal f conveys the current from one plug to the other, and at the same time aids the action of the spiral spring. The result of this balanced

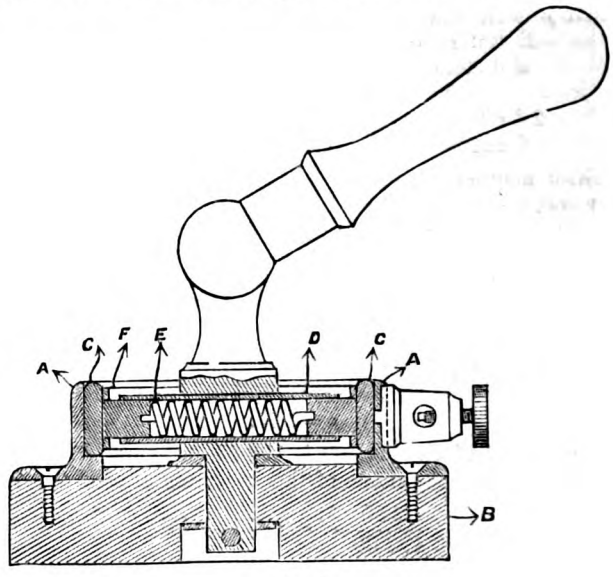

FIG 1.

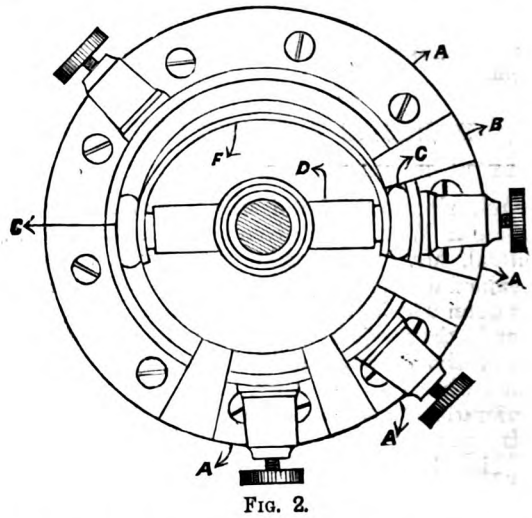

FIG. 2.

action is to make the switch remarkably free to move, and at the same time permits of the desired pressure.

Figs. 3 and 4 show a smaller form of switch, or, more properly speaking, contact breaker suitable for one or more incandescent lamps. Its construction is simple and its action certain. It consists of a short length of riband steel, a, maintained in a bow form by a stiff piece of metal of channel shape, b, with a spindle, c, carrying the handle passing through the spring a, and secured to a cylindrical plug, d, in such a way that the spring and plug move

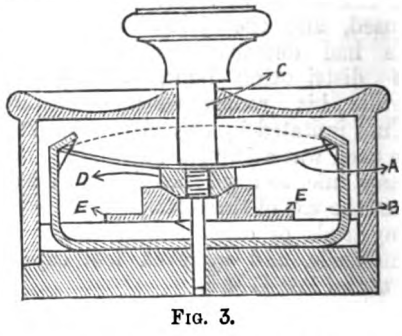

FIG. 3.

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with the spindle, while at the same time the spindle and plug can revolve free of the spring. The plug, in the position shown, presses against two halves of a metal cylindrical base, *e*, to which the wires are attached respectively. The action is as follows:—

If the handle is pulled out from the switch, the plug and spring will pass into the new position, shown by dotted lines, and thus break the circuit, and the spring in passing through its intermediate positions will force out the ends of the metal base or holder *b*, which acts as a powerful secondary spring, maintaining the spring *a* in either of the two positions indicated. From this it will be seen that it is quite impossible to fix the plug and spring in any other or intermediate position, and that the action of making or breaking contact is exceedingly positive and sharp. The revolving play of the plug and handle gives facilities for grinding and cleaning the contacts.

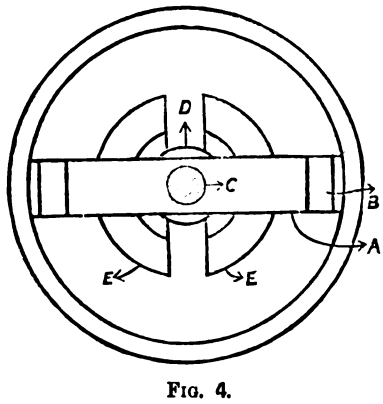

FIG. 4.

We understand that Mr. Thompson has entered applications at the Patent Office for each of these designs.

GREENOCK POLICE BOARD.

The following report by the Electric Lighting Committee to the Police Board was submitted and unanimously approved of at the meeting of the Board on September 10 last:—

"We have to report that the contract for the supply and fitting up of the electric lighting plant at Prospecthill entered into with Mr. E. W. Beckingsale on 10th and 13th October, 1884, was completed on 9th March last and certified by Prof. Jamieson as being in perfect working order. The electrical apparatus has been working successfully since the last date, and on 12th May Prof. Jamieson reported as follows:—

'College of Science and Arts, 38, Bath-street,
Glasgow, May 12th, 1885.

'To the Greenock Police Board Committee on Electric Lighting.

'Gentlemen: I have much pleasure in reporting that Mr. Beckingsale has carried out the electric lighting at Prospecthill in full accordance with your specification and contract. I frequently visited the work during progress, thoroughly tested the whole system upon completion, and again only last Friday, after the lamps had been in action for over 500 hours, I tested the system at work. All my tests are duly recorded in the official test book at Prospecthill. The high insulation resistance maintained in the underground cables and wires is due to great care in handling them, close superintendence during laying them, and a constant application of searching electrical tests. The dynamos and testing apparatus are all of the *best* make and suited for their work.

(Signed) 'ANDREW JAMIESON, Principal.'

"There are 20 street lamps regularly lighted in the area set apart under the provisional order; and three lamps in the machine-house and grounds. Mr. Beckingsale, by his contract, undertook to maintain the whole electrical apparatus for a period of six months after completion, and this period expired to-day (9th September, 1885). The work has been satisfactorily upheld during this period, and the contract is now at an end.

"During the month of August last, arrangements were made with the Roxburgh Street Refining Company, whose refinery is situated within the compulsory area, for a supply of electricity to light their char-house for a period of three years from date of commencement. The fitting up of the apparatus in the refinery was entrusted to Mr. Beckingsale, but the whole cost is payable by the Roxborough Street Refining Company. The rate to be charged for each lamp by the police board is £1 per annum for the time during which the ordinary street lamps are lighted; and the number of lamps is about ninety, which are to be maintained by the Refining Company. The charge will be from 8th September, as the lighting was commenced on that date.

"The total cost of the undertaking is as follows:—

1. Mr. Beckingsale's contract for apparatus, &c...	£873	9	2
Do. do. for maintenance ...	73	0	0
2. Cost of machine house, making trenches, &c...	386	7	6
3. Turbine pulleys and gearing	151	10	0
4. Consulting engineers	51	0	0
5. Expense of provisional order and printing	216	4	10
	£1,751	11	6

"ORDINARY WORKING.

"The maintenance having expired, two men are engaged in attending the machinery, at a total cost of £2. 10s. per week, which, it is expected, will be reduced during the summer months. The renewal of lamps will cost about 15s. per annum each.

"The revenue for the refinery contract and from the public lighting is expected to yield £133 per annum, which will almost meet the cost for wages and upkeep.—Reported by

"Greenock, 9th Sept., 1885." "JN. DUFF, convener.

THE ELECTRIC LIGHT AND ATMOSPHERIC ABSORPTION.*

(Concluded from page 364.)

Relative Intensities of Lights of Different Colours.—Various attempts have been made to assign to each portion of the spectrum its relative illuminating power, the result being a general agreement as to the strong illuminating power of yellow and orange yellow, and the weak illuminating power of blue rays, so that in sunlight, as we see from this table, the specially blue rays only give an illumination of 10 per cent., and in the electric light not more than 20 per cent., so that a cutting off of the blue rays will only cut off from 10 to 20 per cent. of the whole light. When attempts are made to measure more exactly the relative illuminating powers of various portions of the spectrum, we find very considerable differences in the percentage of light assigned to the same part by different observers. This is not remarkable, seeing that Helmholtz has declared that there is no possibility of comparing directly the intensities of two sources of light of different colours. The sensation produced is not in direct proportion to the intensity of the light, and for lights of different colours the sensation and the luminous intensity are differently related. In attempting to measure the intensity of a blue light by means of a standard light of a yellow colour, such as oil or gas, the number expressing the intensity varies with the conditions under which the comparison is made. We can to a certain extent compare differently coloured lights by the ordinary photometers by looking at the images or at the Bunsen disc through some coloured medium placed before the eye, and so determine the relative amounts of red, green, or blue light contained in the two sources of light to be compared. Taking, for instance, copper ruby glass for the red rays, and signal green glass for green and cupric ammonia sulphate for the blue rays, we can accurately compare the lights, determine the relative amounts of red or green or blue light in the two sources of light. The colour of the light depends upon the temperature of the source from which it is produced; a heated platinum wire just begins to give out red light when it reaches a temperature of about 525°C., and as the temperature rises the more refrangible rays gradually appear, until at 1,500°C. the wire gives out a brilliant white light. Carbon poles heated in a vacuum to 1,000°C. give a glow equal to about 30 candles, but on heating them to 4,500°C. the luminous intensity is increased to more than 4,000 candles, the carbons giving out not only light of a high degree of refrangibility and ultra-violet radiations, but being rich also in all kinds of light as well as in obscure heat rays. During the past year interesting experiments have been carried on at the South Foreland Lighthouse on the relative intensities of the most powerful artificial lights with which we are acquainted, and on the general absorption of their light by the atmosphere in different states of clearness. We have only to go back a few years in lighthouse illumination to find as our brightest oil lights either the Fresnel 4 wick lamp or the Trinity House 4-wick lamp of about 300 candles, giving a cylinder of orange-yellow light about 4in. in diameter. By the introduction of the electric light at the South Foreland fifteen years ago, under the advice of Faraday, a source of light of 1,200 candles was obtained within a circle half an inch in diameter. This concentration of the light within so small a space is of vast importance in its use behind a lens, and greatly increases the brightness of the light and the distance to which it can be seen. Its advantages to the mariner are shown from the reports of Profs. Faraday and Holmes on the comparison of these lights, and from a French report in 1870 of the electric light, which says:—"The advantages of the system have been highly appreciated by mariners, and the increase of range of the lights has been very marked in slightly foggy weather. It certainly enables mariners to continue their voyage and to enter a port at night, when they would not have been able to do so with oil lights." A comparison of electric and oil lights of the first order was made by M. Petit, hydrographer to the Belgian Government, some years ago, soon after the electric light was permanently established at the South Foreland. He estimates the relative efficiency of the electric light of 1,200 candles and the oil light of 300 candles, and finds that on 76 nights in a hundred the electric light was seen at a distance

* Evening lecture delivered by Prof. Grylls Adams, before the British Association, at Aberdeen, on Friday, Sept. 11, 1885.

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of more than twenty miles, whereas the strongest oil lights then used were only seen twenty-nine nights in 100 in the same distance. Improvements have been made in oil lights by adding extra rings of wicks, bringing the candle-power of the 6-wick oil light up to 730 candles, and increasing the cylinder of flame to about 4½in. in diameter. In the meantime gas has also been introduced for lighthouse use, and by the addition of ring after ring of burners the largest gaslights regularly used consist of 108 jets, giving a light of 2,400 candles, and giving a cylinder of flame 11in. in diameter. The oil light, 4½in. in diameter, giving a light of 730 candles, and a gas light, 11in. in diameter, giving 2,400 candles, will give beams of light which are more and more divergent as the source of light is larger, and as seen from any point in the axis of the beam appear of equal brilliancy. When placed behind a very powerful lens they are nearly equal in brilliancy to the electric light of 1,200 candles in the permanent lighthouse, which for the last fourteen years have been supplied from the Holmes magneto machine, and in the observations made on the sea the three lights have been seen over the same range. Following M. Petit we may say, then, that both oil or gas have so improved that the practical efficiency has been raised to 76 per cent. But the efficiency of the electric light does not stop at 76 per cent. If we compare the practical efficiency of the permanent electric light supplied by the Holmes machine and the electric light from the De Meritens machine by means of the electric currents which they severally produce, we find in the first a current of 30 amperes, giving an illumination of from 1,200 to 1,500 candles, and in the second a current of from 120 to 150 amperes—ten times the power—giving the light of from 1,200 to 1,600 candles. The effect of this increase of light would be to render this light visible at sea at a distance of twenty miles, through hazy atmospheres, on from eighty-eight to ninety out of every 100 nights in the year. Thus the increase in the illuminating power which is possible with the electric light diminishes the risks to shipping, and raises the practical efficiency of lighthouse lighting from 76 per cent.—the best that can be done by any other means—to 90 per cent., leaving only 10 nights in a hundred when the light is not seen 20 miles away. By a proper arrangement, and more powerful lenses, the efficiency can be still more increased. Of the remaining 10 nights in a hundred there are some when even the strongest lights cannot be seen for a distance of two or even one mile, as has been shown on a few occasions at the South Foreland during the past year. On these occasions the coefficient of transparency of the atmosphere is so small that an increase of 100 fold in the source of light will hardly increase the distance to which the light is seen by 100 yards. Nor can we be astonished at this when a short time since we read that in a balloon enveloped in a cloud 400ft. in thickness, with bright sunshine all around, the observers were carried for long distances in absolute darkness, showing that about 100ft. of cloud is quite sufficient to absorb bright sunlight and cause total darkness. Now let me compare observations made on a very foggy night at the South Foreland (Feb. 12). A compact 6-wick oil light of 730 candles, and a large gas burner giving 2,400 candles, are only just perceptible at the distance of 1,060ft., and both disappear together. An electric light of 12,000 candles, with a smaller lens, is seen at a distance of about 1,350ft. On the same night the glare from the oil and gas was seen in each case to 1,500ft., and the glare from the electric light to a distance of 1,900ft. The lens for the electric light is smaller, and had the same lens been used as is used for oil and gas, other measurements have shown that the light given out from the electric arc would have been twelve times as great, or that an electric light of 1,000 candles with the large lens would have been seen at 1,350ft., and that an electric light of 100 candles would have been seen as far as the strongest oil or gas lights. That in this statement I am well within the mark will be seen by the fact that at the South Foreland a 50-candle incandescent lamp has given, at the distance of 6,000ft., an illumination equal to two-thirds of the illumination of the oil or gas. We have here facts which illustrate two very important principles, each bearing upon the efficiency of the electric light as regards its power of penetration of the earth's atmosphere when used behind a lens. The oil light of 730 candles gives a light which, because of its compactness, is equal in illumination at any point to the gas light of three times the intensity, and the still smaller and more compact electric light, giving a beam more nearly parallel, gives the same illumination. The question may well be asked—How is it that an electric light of 100 candles will penetrate a fog to a distance of 1,000ft., whilst ten times the light of the same kind will only penetrate 350ft. further? Let me try to make clear to you the law of absorption of light by the atmosphere or by any other absorbing medium. Take a beam of light in its course through successive portions of atmosphere of equal length, each successive portion will not absorb the same amount of light, but each successive portion will absorb a given fraction of the light which falls upon that portion, and the quantity absorbed by each portion will depend upon its distance from the source. If, for instance, the first portion absorbed one-half the light, the second portion will not absorb all the remainder, but only one half of it, *i.e.*, one-fourth of the whole; the next portion will not absorb the remaining one-fourth, but only one-half of it, *i.e.*, one-eighth of the whole; so that one-eighth of the whole will have passed through three portions. Take, for instance, a parallel beam of light, such as sunlight, there will be no diminution of this beam as it passes through a vacuum, but in passing through successive miles of an absorbing medium like the atmosphere, a given fraction of the light will be absorbed by the first mile. The same fraction of the remaining light will be absorbed by the second mile, and the same fraction of what still remains will be absorbed by the third mile, and so on, the fraction of any particular kind of light which passes through any mile depending upon the coefficient of transparency of the atmosphere for that particular kind of light. Now let us apply this law to the case of our electric light of 100 and 1,000 candles when the density of fog is such that the coefficient of transparency is ·556 for every 100ft. of thickness. The table I show will give us the quantities of light which pass through the successive layers, each 100ft. in thickness, and we see that in each 400ft. the quantity is diminished to about one-tenth of what it was before. Hence, according to the law of absorption, if a light of 100 candle-power will penetrate fog to a distance of about 1,000ft., then it will require a light of 1,000 candle-power to penetrate to a distance of about 1,400ft. Since the electric light does not give a truly parallel beam, the real distance will be somewhat less than this. Let me quote another instance from the results obtained at the South Foreland with two lights of precisely the same kind to show the rate of increase of light necessary to penetrate a very small extra distance. On one particular evening of dense fog, two gas lights of 2,400 candles each, one above another, are lost at a distance of 1,000ft.; on exactly doubling the amount of light, the light of 9,600 candles in four stages, one above another, was lost at a distance of 1,090ft., the extra 4,800 candles so arranged had only increased the distance by 90ft., showing that for short distances the source of light should be concentrated as much as possible. Let us take another instance which illustrates the advantage of using large lenses with the electric light. The light from the electric light when placed behind the smaller lens was seen to a distance of 1,200ft.; the same electric light behind the larger lens, of about twelve times the power, was seen to a distance of 1,450ft. The light was seen an extra distance of 250ft. when placed behind the larger lens. On May 17, 1884, in a thick and homogeneous fog, the gas lights were seen at a distance of 1,300ft., the oil lights were seen to a distance of 1,500ft., and the electric light at a distance of 1,900ft. On these occasions when the thickest fogs were experienced, we see that it requires a tenfold increase of the light to increase the distance to which it is seen by 300 or 400ft. The very fact that the strongest lights hitherto obtained cannot throw their light farther than 2,000ft. shows us that it is useless for the few nights in the year when such fogs occur to rely on any source of light. For these very exceptional nights it will be necessary to rely on the use of fog horns or on some other mode of guarding the sailor from the rocks, for no lights can penetrate far enough to do him service. Let us look at the reports in just a few cases where the difference in power of two lights may be of great importance. Take the case where a light of 720 candles pierces a fog to a distance of two miles, whilst it requires a light of 16,500 candles to pierce to a distance of four miles. These facts show us that the coefficient of absorption per mile is about ·4, and that about 72 candles would be required if it is to be seen to the distance of one mile, and about 4,000 candles to penetrate to a distance of three miles. On Sept. 6, the revolving lights were exhibited from 10:45 to 11:45 in thick rain; on a lightship at a distance of 10½ miles the electric light became visible at 11 o'clock, but the gas and oil lights at full power were not seen until 11:35 p.m. On Nov. 23, a hazy night, fixed lights were exhibited from 9:40 to 10:15, but at Ramsgate the electric light only was visible. On Dec. 1, the lights were exhibited revolving on a dark and hazy night. At Ramsgate, 11½ miles off, the gas and oil lights were not visible after 8:30 p.m., whilst the electric light was very powerful until it was put out at 12 o'clock. At the Gull Lighthouse, eight miles off, all the lights were seen throughout the evening. On Nov. 26 there is another instance which shows that at a distance, as well as near at hand, the most powerful gas light yet used in lighthouses, in four stages one above another, does not penetrate farther than the single permanent light of the South Foreland Lighthouse as set up by Faraday fifteen years ago. The gas and the permanent electric light disappeared together at a distance of 12½ miles, but the experimental electric light was visible as far as the vessel steamed, *i.e.*, up to 14½ miles. Or take again, as a last instance, the observations of January 24 of the present year, when at the Varne lightship, 12 miles from the lighthouse, the electric light was seen throughout the evening, but no other light was seen. All these cases of fog and partial fog are included in those 10 nights in 100 of which I have spoken, and we see that probably in half of them the new electric light would be sufficient to prevent disaster to our shipping, leaving only 5 per cent. of nights of thick fog when no light can be sufficient. In order to study the effects of very dense fogs in eclipsing powerful lights, steam was allowed to issue from the steam pipes introduced into the photometric gallery 380ft. in length at the South Foreland Lighthouse. The steam was let out at various points, so as to fill the gallery with a dense and fairly homogenous mass of condensed steam, the supply being kept up from points farther away from the lights than the observer was. Such a mixture of air and condensed steam may fairly be taken to represent a dense sea fog or genuine Scotch mist. Let me give you the results of some of my experiments made in this gallery. At one end of this gallery were placed a 108-jet gas burner, giving an illumination of about 2,500 candles, and a De Meritens arc lamp giving a light of about 12,000 candles. These were alternately eclipsed by placing a screen in front of first one and then the other. Such was the density of the fog which could by this means be obtained, that in the gallery when daylight was shut out, at a distance of more than 100ft. I could see no light at all, not even the slightest illumination of the fog, and the eclipsing or exposing either light made not the slightest change whatever in the state of gloom. No light sufficient to affect the eye penetrated the fog to a distance of more than 100ft. From 90 to 100ft., when the electric light was exposed there was just the faintest possible illumination of the fog in the general direction of the source of light, but when the gas was exposed not the slightest illumination could be seen. On approaching nearer, the illumination from the electric light became brighter, but when that was eclipsed there was no illumination whatever from the 108-jet gas until a point of 65ft. from the source of light was reached. From 60ft. to 65ft. there was just a faint illumination of the fog from the gas light; at this distance the fog was well illuminated when the electric light was exposed, but the source of light, the electric arc itself, could not be seen. On approaching nearer, at 50ft., the glowing 40-millimetre carbons became visible, not as a single point of light but of the full breadth of the car-

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bons. On approaching still nearer the gas flames themselves were not seen, until at a distance of 36ft. the whole breadth of the flame came into view at once, and the direction of the source became accurately defined. In another series of experiments, on going away from the flames, the gas flames were seen up to a distance of only 30ft., and the glowing carbons of the electric arc went out at 40ft. In these experiments with the fog in the photometric gallery my observations agree with those made by Mr. Dixon, and taking the value which he gives for the relative distances to which the electric light and gas were seen, I have deduced the coefficient of absorption per every 100ft., and shown by a table the law of diminution with the distance. It is not right to assume, as some have done, that the light coming through different distances of fog varies inversely as the square of the distance, for this law does not apply. An interesting experiment was made with the electric light of 12,000 candles and the Douglass standard of one candle-power in the steam fog. It was found that the glowing carbons, 40 mm. or 1⅝in. wide, was seen to a distance of 80ft., and the one candle standard, ¼in. wide, was seen to a distance of 40ft., and with the same coefficient of transparency the 108-jet gas would have been seen to a distance of 60ft. Again, the glowing carbons in another experiment were seen to a distance of 117ft., and the standard one candle to a distance of 55ft., and with the same coefficient of absorption the 108-jet gas was seen to a distance of 80ft., and a single gas jet was seen to a distance of 70ft., showing that the distance to which a light is seen in fog depends on the intrinsic brightness of the flame, and that an increase in the size adds very little to the pentrative power. The observations made as to the *character* of the illumination in these dense fogs are very important, and directly illustrate the subject of my lecture. When first the faintest illumination from the electric light became visible at from 90 to 100ft. the illumination was not red or yellow but white, like moonlight (those who speak of a yellow light as white would call it blue), and at any and all distances there could be no question whatever as to the source which was giving the light. Whenever the electric light was exposed the illumination of the fog was white, but whenever the gas was exposed the illumination was yellow or orange yellow. The illumination of the fog was of the same colour as the source of light, showing that with a mixture of air and vapour in the form of steam, forming a cloud without the admixture of other substances, rays of different colours were absorbed, and scattered very nearly in the same proportions. Here also Mr. Dixon's observations agree with mine, for he says, "Long before the actual lights were seen, the fog was brightly illuminated by the lights, the *blue* tint of the electric light greatly predominating." In this case those blue rays, which some say are so readily cut out, can still be seen. This shows that the proportion of the electric light which is scattered by such a fog is no greater than the proportion of any other source of light. During these experiments with steam, a pocket spectroscope clearly revealed the rain bands in the yellow, near the sodium lines, and other rain bands in the yellowish green and blue, showing that the true selective absorption of the molecules of water vapour is not specially confined to the blue end of the spectrum. We may to some extent illustrate the action of a mixture of air and vapour upon a beam of light by experiments with tubes, into which the mixture may be introduced. Taking a beam from the electric arc, and sending it through a tube containing air which has been cleared of particles of dust by being filtered through cotton wool, we get a clear beam through the room, and by a lens we may get a clear image of the opening, or of a slit upon a screen. On introducing vapour of water by passing air through water there is no condensation, and the image is still clear, but when particles of dust are by any means introduced into the tube, the vapour becomes condensed into water around the particles of dust, and the masses of molecules so collected scatter and reflect the light in all directions without producing colour. What, then, may we gather from these experiments at the South Foreland as to the relative intensities of the electric light in lighthouses as compared with other lighthouse lights? The experiments have shown that, using the large Mew Island lens with the Wigham gas-light of 2,400 candles, and the smaller lens with the electric light of five times the power, or 12,000 candles, the electric light in clear weather was at least sixteen times as bright, and in foggy weather was about thirteen times as bright as the gaslight, the excess of absorption for the electric light being about 20 per cent. more in foggy than in clear weather. The experiments have also shown that the electric light is at least of twelve times the intensity with the large Mew Island lens as with the smaller lens; hence the illumination which would be given to the mariner from the electric light by using the same lens as for gas is from 150 to 250 times as great as is given by the gas. If we take lights of the two kinds of equal intensity, the electric light in thick weather will give the mariner thirty times the light and in clear weather about forty times the light which is given by the gas. By employing two De Meritens machines, giving a light of about 18,000 candles, the electric light in foggy weather will give the mariner more than 60 times the light which he has hitherto obtained from four Wigham gas burners of the largest type placed one above another. If we compare electricity with a single new Douglass 10-ring gas burner, the strongest light other than electric which has been tried for lighthouse work, and which has been seen at the Gull light vessel eight miles off when oil and 108-jet gas burners were obscured by fog, we find that the electric light in fog sends out a beam which is from 100 to 150 times as bright. As regards the question of the relative absorbing power of the atmosphere in different kinds of weather for the different lighthouse lights, the principles which I have attempted to explain as to the greater absorption of the atmosphere of blue rays than of red, and the fact that the electric light, while abounding in all, is especially rich in blue rays, would lead us to expect that the illumination from the electric light will be weakened somewhat more than gas or oil in foggy weather. Although this does not appear in the case of the steam fogs, yet the other measurements made at the South Foreland show a somewhat greater weakening of the electric beam.

COMPANIES' MEETINGS.

The Electric "Sun" Lamp and Power Co. (Limited).

The third ordinary general meeting of this Company was held at the Cannon-street Hotel on the 22nd inst. Mr. William Perkins presided.

The SECRETARY (Mr. F. R. Boardman) read the notice convening the meeting. In their report the Directors stated, *inter alia*:—"We are reluctantly compelled to come to the conclusion that until the Board of Trade adopt the modifications and changes in the Electric Lighting Act suggested by the Electric Lighting Act Committee in their report of March last, we cannot hope to succeed. We have found that the general public are unwilling to incur the heavy expense of separate private installations, however good the systems may be; and the restrictions of the present Act effectually bar the employment of capital for the installation of works for a general supply of electricity; and it is quite certain that had gas when first introduced been hampered with the same restrictions which have been imposed upon electric lighting, it never could have survived them or have attained its present great success. In fact our field for work is reduced to such a small compass that we regret to say we cannot see our way to make the undertaking sufficiently profitable to continue it."

The CHAIRMAN said: We have entered fully in our report upon the working of the Company in the past 18 months. We were appointed with the view of seeing whether we could bring this thing out of its despondent state at that time. Some of the Directors were anxious to wind up the Company at the last ordinary meeting, and others were anxious to go on. It was thought that if we had a fresh trial we could possibly make a success of the Company. At any rate, the trial was thought worth while making. As soon as we assumed office we went to work to curtail the working expenses of the Company. We gave up the offices at Westminster and removed to Ridinghouse-street, where the Company had premises; and altogether we reduced our working expenses to the extent of some £1,500 a year. We then appointed agents in every principal town of England, Scotland, and Ireland, with the view of seeing whether the Sun lamp could be introduced to the public. We improved upon the lamp and employed the inventor of the lamp himself, M. Clerc, who had some fault to find with the construction of the lamp as it then came under our notice. He made various improvements in it, and has so far succeeded that at the present moment we as Directors look on it as of very much more value than when we took it over. He has succeeded in making the lamp workable in parallel as well as in series—that is, that the dynamo in use for working other lamps can be used for working the Sun lamp. That is an enormous advantage over its original state. When we had appointed our agents in the country we also appointed a traveller and a manager. The latter had had very considerable experience in establishing at the outset the telephone work, and we thought he would be a valuable acquisition. We had very high testimonials and recommendations of him as to his energy; and he devoted quite a year to pushing the lamp, and endeavouring to introduce it among private individuals, and at picture galleries, theatres, music halls, and elsewhere. The traveller, whom we appointed on salary and commission, canvassed the country generally. We issued circulars to the public. We contracted to light a portion of the Health Exhibition, and now of the Inventions Exhibition, and since the last meeting we have taken two gold medals and one silver medal for the lamp. When, however, it came to a question of the public really adopting this or any other form of lamp we were met by this difficulty—that the late Government had placed such restrictions on the manufacture and supply of the electric current that we, like the other companies, found it would be madness to invest our capital, large or small, in establishing a central station for the supply of electricity. The whole of such capital as we had would have been absorbed in putting up one installation alone from the central station, and the Government, or the local authorities, would have had the right at the end of 15 years to take that from us at its then value. We considered that it would have taken nearly 10 or 15 years to have established the value. However, our money would have been sunk, and the value of our plant, after 15 years' wear and tear, would have been very small indeed, as compared with the cost to us. Therefore it would have been, and would be, madness to establish a central station, and it is a known fact that not one of the electric light companies have cared to or will incur the expenditure of a central station for supplying the current of electricity till the Government have modified the Electric Lighting Act, and placed electric light companies who go in for the production of the electric current for lighting purposes on an equal footing with gas companies. Many of the companies that were formed were formed simply for the purpose of supplying a special lamp. We were formed partly for that purpose, but at the same time for the purpose also of supplying the current necessary for the working that lamp. My own opinion is that the future of electric light companies will be that the producing company—that is, the company supplying the current—will be independent from the company that supplies the lamp, and that the companies which supply the electric current necessary for working the lamp will be in the same position as gas companies, the owners of special forms of lamps being in the position of chandelier makers, and makers of gas burners and fittings. The supply of electricity must be—and will be, I think—entirely independent of any special form of lamp. We have a special form of dynamo, which is well adapted for the production of the electric current for general supply, and doubtless when the Government give the necessary facilities for its production and distribution, the dynamo we have will be adopted by such producing companies, if not by ourselves. That our lamp has proved to be a practical success is demonstrated by its adoption at the Grosvenor Gallery, and by the high praise it has received at both the Health and the Inventions Exhibitions, and from every one, in

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fact, who has seen it, no matter where. We have installations at the present time at the Grosvenor Gallery, at the Inventions Exhibition, at the *Manchester Guardian* office, and at two or three other places, but they are altogether insufficient to warrant us in continuing the working of the Company. Finding that we could not dispose of large installations, we turned our attention to canvassing London districts to see if we could get private individuals to adopt any system of electric light; but their reply was, "If you will supply the current we have seen sufficient of your lamp to induce us to adopt it; but we ourselves are not going to be producers of the necessary current of electricity to work the lamp. If we were to put a dynamo and engines on our premises, no matter where, if in a populous neighbourhood, we might be indicted." Therefore, they say, till you can take your manufactory away from a populous district, where there is no difficulty, and produce it as gas is produced, we decline to adopt it. Otherwise, even though it cost us double our present gas bill, we would adopt it, but we will not become producers ourselves. The Directors, therefore, have nothing but to admit that at present we do not see our way to carry on the business of the Company successfully. In fact, the proof of the last eighteen months is that it has cost £2,750 beyond what we have taken into stock. Our loss during the time we have been in office has been £4,147. That is over a period of eighteen months, and we have worked as economically as possible. We think the fairest and most candid manner to deal with the Company's assets at the present time is this—We have practically in hand and owing to us some £6,000 at the present moment, and at the present rate of expenditure we could go on for another year or two. It would, however, be useless to spend that money, and we have come to the conclusion that it would be more advisable to distribute the cash assets at once among the shareholders, retaining the patent till the Government see fit to remove the restrictions they have imposed on electric lighting. We also propose to retain the plant. We have plant sufficient for several installations, and we propose that an immediate division of the cash assets of the Company should take place, and that the realisation of the stock of lamps, dynamos, and engines, and the other apparatus necessary for the installation of electric lighting, shall be disposed of as the demand arises. In that way we shall not have to put up with the sacrifice which we should otherwise have to bear. If we went to a forced sale now, we should get a "mere song" for the plant we have, whereas, if you wait, I think the time is not far off when the Government will see the absolute necessity for granting facilities for electric lighting. We have in addition to that stock, as I have said, our patent, which may be sold to a company that may be formed to acquire it, or to any of the existing companies who require the form of lamp we have, or the liquidators may see fit to grant licences to the manufacturers of electric lighting installations and apparatus, with a view to their making and supplying these lamps, or this special form of lamp, to the public. We have done our best in trying to make a success of the Company, but we have failed—failed simply from no fault of our own. We have done, I believe, our best. The Government have not seen fit to give us any facilities to make a success of the electric lighting enterprise; the public will not become producers of the current necessary to light our lamps or any other lamp, and, therefore, we have reluctantly come to the decision to advise you to take the course suggested in the report, namely, to divide the cash assets, and to realise the plant and patent as opportunity arises. I now beg to move that the report and accounts be adopted.

Mr. M. I. F. BRICKDALE seconded the motion.

Mr. DUCHAMP said he thought that the course proposed by the Directors should be followed, but he thought that Mr. Henry de Grelle should be added to the liquidators.

The CHAIRMAN pointed out that the suggestion mentioned might be dealt with at the extraordinary meeting. He then put the motion, which was carried unanimously.

The SECRETARY next read the notice covening the extraordinary meeting, at which, it was stated, the following resolution would be submitted:—"That the Company be wound up voluntarily under the provisions of the Companies Acts, 1862 to 1883, and that William Perkins, of York Villa, Princes-terrace, Bayswater, Esquire, and Matthew Inglett Fortescue Brickdale, of 8, New-square, Lincoln's Inn, Barrister-at-law, be and they are hereby appointed liquidators for the purposes of such winding up."

The CHAIRMAN having proposed, and Mr. BRICKDALE having seconded the above resolution, it was agreed to unanimously.

Mr. DUCHAMP then proposed that Mr. De Grelle should be appointed one of the liquidators, a large number of the shares being held, he stated, by Belgian gentlemen.

M. CLERC seconded the motion.

The CHAIRMAN stated that the Directors had no objection to the proposal, and in reply to a question, he added that Mr. De Grelle was one of the Directors. The motion was carried unanimously.

A SHAREHOLDER inquired whether any decision had been come to as regarded the remuneration of the liquidators.

The CHAIRMAN replied that the solicitor had informed him that there was no regular scale for such services, and had suggested that it was a matter which would come before the shareholders at a future meeting. They were all in the same boat. Mr. Brickdale, who was the largest shareholder of the Company—holding £5,000 in the shares—was certainly likely to look after his own interests, and in doing so he would be looking after those of the other shareholders.

On the motion of Mr. THACKER, seconded by Mr. SIMPSON, a vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN acknowledged the compliment, and in reply to a question, said that the moment anything arose with regard to the disposal of the patent, the shareholders would certainly be called together. There would be another meeting to confirm the resolution which had been passed that day for the winding-up of the Company.

The proceedings then terminated.

COMPANIES IN LIQUIDATION.

We extract the following notices from the *London Gazette*:—

The Pyramid Electric Light Company (Limited).—Notice is given that a general meeting of this company will be held at the offices of Messrs. W. H. and F. S. Collins, St. Mary-street, Ross, Herefordshire, on the 16th day of October, 1885, at 12 o'clock at noon precisely, for the purpose of having the liquidators' accounts, showing the manner in which the winding up has been conducted, and the property of the company disposed of, laid before such meeting, and of hearing any explanation that may be given by the liquidators.—Dated the 11th day of September, 1885.—(Signed) F. W. T. Brain, liquidator.

Electric News Telegraph Company (Limited).—Notice is hereby given that a general meeting of this company will be held at 4, Ludgate-circus, E.C., on the 24th day of October, 1885, at two o'clock in the afternoon precisely, for the purpose of having the liquidators' accounts, showing the manner in which the winding up has been conducted, and the property of the company disposed of, laid before such meeting, and of hearing any explanation that may be given by the liquidator.—Dated the 12th day of September, 1885.—(Signed) Wm. J. Burnside and B. P. Daniels, liquidators.

Provincial Brush Electric Light and Power Company (Limited).—The creditors of this company are required, on or before the 3rd day of October, 1885, to send their names and addresses, and the particulars of their debts or claims, to William Henry Pannell, the liquidator of the said company, at the registered office of the said company, 38, Basinghall-street, in the City of London, or in default thereof they will be excluded from the benefit of any distribution of the assets of the said company made before notice of such debts or claims have been received by the said liquidator.—Dated the 15th day of September, 1885.—(Signed) Wm. H. Pannell, liquidator.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. SEPT. 23.		BUSINESS DONE WEEK ENDING SEPT. 23. Highest.		Lowest.	
Anglo-American	29,	30		29½		29½
Do. Preferred	49,	50		51½		49½
Do. Deferred	8,	8½		8½		8½
Brazilian Submarine	10⅞,	11⅛		11		—
Cuba	11⅛,	12⅛		—		—
Do. Preference	18,	19		18¾		—
Direct Spanish	1½,	2		—		—
Do. Preference	11⅜,	12½		12½		—
Direct United States Cable	8½,	9		—		—
Eastern Telegraph	11½,	11⅝		11 7-16		10 11-16
Do. 6 per Cent. Preference	13½,	14		13 9-16		13⅜
Do. 5 per Cent. Debentures, 1899	105,	108		—		—
Eastern Extension	12½,	12⅝		12 9-16		11⅞
German Union	8⅞,	9½		—		—
Globe Telegraph and Trust	6⅞,	7½		7½		6 15-16
Do. Preference	12⅝,	13⅛		13½		13
Great Northern	13½,	14		13⅝		13⅝
Indo-European	30½,	31½		—		—
Reuter's	7½,	8		—		—
Submarine	190	200		199		195
West India and Panama	⅝,	⅞		11-16		—
Do. 1st Preference	8,	8½		8½		8½
Western Brazilian	5⅝,	5⅞		—		—
Western Union 7 per Cent. 1st Mortgage	120,	124		—		—
Do. 6 per Cent. Sterling Bonds	100,	102		—		—

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	⅝		15-16		⅝
Oriental	½,	⅝		5-16		—
United Telephone	11½,	12		12		11⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1⅞,	2⅛		2⅛		2⅛
Do. (fully paid)	3½,	4		4		3⅞
Hammond Light (£3 15s. paid)	1-16	3-16		—		—
Swan	½,	⅝		—		—
Maxim-Weston	½,	⅝		—		—

MISCELLANEOUS.

Telegraph Construction	35½,	36½		36½		35½
India Rubber, Gutta Percha, and Telegraph Works	23,	24		24		23½

TRAFFIC RECEIPTS FOR AUGUST, 1885.

COMPANIES.	Aug., 1885.	Aug., 1884.	Increase.	Decrease.
Brazilian Submarine	11,896	—	—	—
Cuba Submarine	2,200	2,515	—	315
Direct Spanish Telegraph	1,276	1,190	86	—
Eastern Telegraph	47,968	45,329	2,639	—
Eastern Extension	41,987	39,463	2,524	—
Great Northern	24,000	—	—	—
Western and Brazilian	7,158	—	—	—

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NOTES.

THE TANNERGRAM!—It is suggested that the new sixpenny telegram shall be called "Tannergram."

ATLANTIC CABLE COMPETITION.—It is expected that a rate-cutting contest is about to begin among the Atlantic cable companies.

CHEAP TELEGRAMS.—An article on cheap telegrams appears in this month's *Fortnightly Review* from the pen of Mr. Charles Cameron, M.P.

GERMAN ASSOCIATION.—The fifty-eighth meeting of the German Association of Naturalists and Physicists was held at Strassburg, Sept. 17—23.

THE ELECTRIC LIGHT IN TEXAS.—It is stated that the Edison Company is contracting to light the City of Dallas, Texas, with incandescents.

CHEAP TELEGRAMS AND THE PRESS.—The Postmaster-General notifies that no alteration is to be made in the mode of counting Press messages under the new tariff.

THE ANTWERP EXHIBITION.—Rumours are afloat as to the probable time of the closing of this Exhibition. In any case it will remain open, we are informed, until the 12th prox.

THE TASMANIAN DUPLICATE CABLE.—Advices from Tasmania state that the steamer "Sherard Osborn" was to leave Singapore immediately with the new duplicate cable for Tasmania.

THE CROYDON ACCIDENT.—On the occasion of the late accident on the South Eastern Railway at Croydon several telegraph poles were knocked down and the wires disconnected.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the weeks ended 11th, 18th, and 25th Sept. amounted to £2,388, £2,758, and £2,986 respectively.

FREEMASONRY.—On Saturday last the Electric Lodge held their last meeting of the year. Messrs. H. Crookes and J. E. Spagnoletti were raised, and Mr. W. H. Preece was elected Master for the ensuing year.

THE RIVER PLATE TELEPHONE AND ELECTRIC LIGHT COMPANY.—This company notify that coupons due on the 1st of October next will be paid, less income tax, on and after that date at the Alliance Bank, Bartholomew-lane, E.C.

THE CANADIAN NORTH-WEST.—The new railway will afford communication between the cattle ranches on the slopes of the Rocky Mountains and Manitoba and the East. A telegraph line has also been constructed in connection with it.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the weeks ended 18th and 25th Sept. were £1,780 and £1,201 respectively, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE TELEGRAPH REVENUE.—The Revenue returns for the past quarter show that the telegraph revenue has increased by £5,000 as compared with the corresponding three months last year, and has increased £20,000 for the year ending 30th September compared with the year ending September, 1884.

SARCASM.—At a recent meeting of the Bingley Improvement Commissioners, one of the members observed that he believed the Telephone Company had more regard to private property than the Board. If this be so, private property in Bingley, between Board and Telephone, must have a bad time of it.

THE ELECTRIC LIGHT AT LIVERPOOL.—At a recent meeting of the Mersey Docks Board it was resolved to accept the tender of Messrs. R. E. Crompton and Co. to supply the apparatus and lantern required in connection with the proposed adoption of the electric light upon the new lightship now being built for the Bar station.

A NEW CABLE FOR WESTERN AUSTRALIA.—The telegraph cable for connecting Breaksea Island with King George's Sound has been successfully laid. It was expected that the work of signalling vessels passing Breaksea Island, and reporting the fact by means of the cable would be inaugurated in the course of a short time.

A NEW ARC LAMP.—An arc lamp, constructed for the purpose of projecting a single ray of intense brightness, was recently described by the *Elektrotechnische Zeitschrift*. This is the invention or rather design of Mr. R. Ruhlmann. Those interested in search lights might do worse than look at this new model of the arc lamp.

THE BESSBROOK AND NEWRY TRAMWAY.—The official report of the Board of Trade inspectors who inspected the Bessbrook and Newry Electrical Tramway last week, has been received. The inspectors speak in high terms of the line, which was to be opened for traffic yesterday. It is the second electrical tramway constructed in Ireland.

THE EARTHQUAKES.—It is stated by the Russian *Official Messenger* that repeated shocks of earthquake have been experienced all through the summer in the town of Namangan, in Ferghana. The most violent of the shocks occurred in the months of April (the 17th) and August (4th), but were not attended with any very serious consequences.

THE FRENCH TELEGRAPHS.—By the decree of the Minister of Posts and Telegraphs, dated the 7th ultimo, the opening of telegraph offices is authorised in the following communes:—Cognac-Lyonne (Allier), Praixan (Aude), Parsenans (Jura), Saint-Germain l'Espinasse (Loire), La Recousse-Zouafques (Pas-de-Calais), and Argenton-l'Eglise (Deux-Sèvres).

ELECTRIC TRAMWAYS ON THE CONTINENT.—In the collieries of La Peronnière, near Rive-de-Gier, Thibault, near Saint-Etienne, and Saint-Claude, near Blanzy, in France, electric tramways are in full and satisfactory operation. Tramways on the same principle have also been laid down in German collieries, and Belgium is soon to possess a similar line.

THE TELEGRAPH IN EASTERN ROUMELIA.—The postal and telegraphic tariff in Eastern Roumelia has been assimilated to that in Northern Bulgaria, and the authorities have apprised the International Bureau at Berne of the fact. Telegrams to both of these countries, however, are at present subject to considerable delay, owing to the disturbance in political affairs.

TESTIMONIAL.—The following testimonial, dated the 16th February, 1885, has been received by the Kinetic Engineering Company from the Imperial Austrian Ministry of Commerce:—"The last tests made by the Department of Posts and Telegraphs at Insbrück have proved that the cables which you have furnished for the Arlberg Tunnels remain, both as regards conductivity and insulation, in a condition completely satisfactory."

ELECTRIC LIGHTING AT EXETER.—At a recent meeting of the Town Council the tender of the Consolidated Electric Company for the installation of the electric light at the new asylum at Digby's was accepted, and the Town Clerk was instructed to communicate with several electrical engineers unconnected with any company, and ascertain the terms upon

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which they each would act as consulting engineer to the Corporation.

TELEGRAPH WORK ON THE CONTINENT.—During the interview between the Emperors of Russia and Austria, at Kremsier, the local telegraph office forwarded, on the 29th of August, 295 messages, representing 27,700 words ; on the day following 338 messages (33,400 words) were sent, and on the 26th 390 messages (26,700 words), making a total of 1,023 messages and 87,800 words for the three days. These were all sent on a single Hughes type writer.

BOTTOMLESS AMBITIONS.—Amongst the more remarkable of the attempts of recent years to set the Thames on fire the following should be remembered and credited to the year 1885 :—The "French International light tower, Paris all there and the rest nowhere." "Oceanic Telegraphy with a vengeance ; cable stations every two miles across the Atlantic." "A Federation of Nations to purchase the Submarine Cables ;" and "Unlimited Telephony, or round the world by telephone for two pence."

THE PULUJ INCANDESCENT LAMP.—The filament in the Puluj incandescent lamps, now manufactured at Steyr, in Austria, is apparently of Manila fibre, and is arranged in the somewhat curious form of a hand having three fingers. This carbonised filament is said to present a remarkably uniform surface and to be of great strength. The average resistance of the lamp is about 214 ohms (cold presumably), giving, with a difference of potential of 20 volts at the terminals, 20 candle-power. Their life is fixed at 1,000 hours.

REWARD FOR GALLANT CONDUCT.—On Wednesday morning the Mayor of Dover presented a young man named M'Cudden, a telegraph clerk, with the bronze medal and certificate of the Royal Humane Society. M'Cudden was engaged at the Dover Telegraph Office recently, when he saw a private of the Royal Irish Regiment fall into the harbour. One of the soldier's comrades jumped in after him, and M'Cudden ran from the office and plunged into the harbour after them, rescuing both men, neither of whom could swim.

THE TELEPHONE IN SWITZERLAND.—Direct telephonic communication will before very long be established between Berne, Thun, and Solothum. The Telephone Exchange at the Lake of Geneva has already a list of 1,272 subscribers. Zurich alone has some 1,350 instruments connected to two central stations. There are in the town 1,100 subscribers, the remainder being distributed through nine suburban villages, the latter also, of course, being in direct communication with the central stations. In comparison with Bâle, Zurich possesses twice the number of subscribers.

THE BLACKPOOL ELECTRICAL TRAMWAY.—On Tuesday last the inauguration of the Blackpool electrical tramway—the first street tramway of the kind in England—was celebrated. The Mayor of Manchester guided an electrically propelled car for a considerable distance over the line, which is some two miles in length, amid considerable applause. The inaugural ceremony was followed by a banquet, at which Colonel Stanley, M.P., Mr. Tomlinson, M.P., the Lord Mayor and Lady Mayoress of York, and some forty Mayors and Mayoresses of Lancashire, Cheshire, and Yorkshire were present.

THE TELEPHONE IN RUSSIA.—It is somewhat a matter of surprise that the telephone contrives, commercially speaking, to live in Russia, let alone to flourish. The rules and regulations which govern the formation of telephone companies in that country are, to say the least of them, rigorous, in that the Treasury lays claim to 10 per cent. of the private subscriptions and 5 per cent. of those of municipal and Government corporations. The revenue derived from this source amounted in 1883 to some 22,000 roubles, and that for 1885 is confidently expected to realise no less than 40,000 roubles, or about £6,500.

TELEGRAPHIC COMMUNICATION WITH SOUTH AFRICA.—The following letter has been written to *The Times* by Mr. W. J. Tyler, the secretary of the India Rubber, Gutta Percha, and Telegraph Works Company :—"With reference to the letter in *The Times* from 'X,' in which letter we are referred to as the Silvertown Company, we beg to say that we have completely manufactured and are now shipping cables to be laid from the Cape Verd Islands to the West Coast of Africa, in accordance with concessions from the Governments of Portugal and France, and these cables can easily be connected with the possessions of other Governments in West Africa if so desired."

PERSONAL.—We are informed that Mr. Townsend, lately district manager in Inverness for the National Telephone Company, has been appointed district manager of the newly-formed Scottish South Central District. The district embraces the counties of Fife, Kinross, Clackmannan, and Stirling, with head-quarters at Kirkcaldy, and from the extent of the circuit must in its management of necessity prove much more responsible than the position which Mr. Townsend has resigned. Mr. R. C. Bennett, who has been assistant at Inverness since the opening of the Exchange, and who thoroughly understands the work, will take charge in Inverness, and under his management the Exchange will no doubt be carried on as successfully as hitherto.

NOTICE OF REMOVAL.—The following companies have removed from 66, Old Broad-street, E.C., to Winchester House, 50, Old Broad-street, London, E.C. :—The Eastern, the Eastern and South African, the Eastern Extension Australasia and China, the Submarine Cable Trust, the Globe Telegraph and Trust Company, the London Platino-Brazilian Telegraph Company, the Black Sea Telegraph Company, the German Union Telegraph and Trust Company, and the German Union Telegraph Company of Berlin. The London telegraph stations of the Eastern and the Eastern and South African Companies remain unaltered, viz. :—No. 11, Old Broad-street ; No. 3, Great Tower-street ; No. 8, Leadenhall-street ; No. 41, Parliament-street, S.W.

A PHENOMENON IN ARC LAMPS.—Mr. Levett, in the *Electrical World*, describes a curious phenomenon which was noticed upon the negative carbon of an ordinary arc lamp being replaced by a piece of copper filed to a blunt point. Instead of fusing, there was merely a slight melting of the point on first starting, after which no further melting of the copper took place. There seemed to be a deposition of carbon particles carried from the positive electrode of carbon to the negative electrode of copper which tended to shield the copper. Mr. Levett had a piece of copper taking the place of carbon for three weeks without perceptible diminution in weight. His experiments were conducted on a circuit of 20 amperes, and length of arc of $\frac{1}{32}$in.

DIVIDENDS.—The directors of the Eastern Extension, Australasia, and China Telegraph Company announce an interim dividend of 2s. 6d. per share for the quarter ended 30th June last together with a bonus of 2s. per share, both free of income-tax, payable on 15th inst.—The directors of the Globe Telegraph and Trust Company, at the board meeting held on the 29th September, declared the payment of an interim dividend on and after the 23rd inst. of 3s. per share on the preference shares, less income tax, and of 1s. 6d. per share on the ordinary shares (income tax having already been

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deducted) for the quarter ending the 18th October. The transfer books were ordered to be closed from 15th October to 23rd October, both days inclusive.

THE MEXICAN TELEGRAPHS.—The Government telegraphs in Mexico do not seem to be in a very flourishing condition, if the following figures may be taken as a criterion. The estimates for this year are :—

	Fr. ct.
Salaries	3,066,709.50
Maintenance	2,100,000.00
Construction of new lines	750,000.00
Total	5,916,709.50

The last annual report gave the receipts as :—

Ordinary messages	1,115,854.65
Official messages	3,084,829.20
Total	4,200,683.85

The mileage is about 21,000 kilometres (13·02 miles).

KISSING GOES BY FAVOUR!—This is a remark that was perhaps never more *apropos* than of certain events which took place in connection with the late meeting of the British Association at Aberdeen. Tickets for anything special were not to be had by the smaller fry of electricians and journalists for love or money. Several of the latter, in the interests of the papers they represented, became associates for the mere purpose of accompanying the members on certain of their perambulatory visits. These gentlemen, however, were frowned upon ; and those who here in London have approached Royalty in the ordinary course of their business were rigorously forbidden even to mention the name of Her Gracious Majesty in the hearing of autocratic Aberdeen. Hoot, mon !

SOUTH AUSTRALIAN TELEGRAPHS.—Mr. Charles Todd, Postmaster-General of South Australia, has written as follows to *The Times* Berlin correspondent :—"I have read your telegram in *The Times* with much interest ; but I trust you will allow me to call your kind attention to two omissions, no doubt caused by want of full information, viz., that with a view to a reduced through rate of 8s. 8d. on private messages South Australia will reduce her rate for transmission over the land line between Port Darwin and Adelaide from 1s. 3d. to 1s. 1d. per word ; and to effect a reduction on Press messages to 2s. 8d. per word she will reduce her rate from 1s. 3d. to 4d. per word. In connection with these reductions I should mention that South Australia has expended £500,000 in the first erection and subsequent re-poling with iron poles of the line across Australia, and that she sustains an annual loss of about £25,000, including interest on outlay."

CONTINENTAL NOTES.—The electric light in the Theatre de l'Eldorado at Paris continues to give great satisfaction. It will be remembered that the installation was put down by M. Cance.—The exhibitors at the Palais de l'Industrie are said to be preparing a petition with the object of obtaining the electric light in the Exhibition during the evening.—Great success has attended the experimental lighting of the Palais Royal, Paris. At present the number of incandescent lamps in the installation is 150. The Theâtre Français, Theâtre du Palais Royal, and the Council of State have, however, now approved of the deed of agreement signed by the tradespeople, so that a large number of lamps may reasonably expected to be in operation at an early date. Extensive experiments are now being carried out with the object of determining the best lamp to be used.—It is announced that the new branch of the Thomson-Houston Company will commence operations in Liège next month.—At the request of M. Déroulède a telegraph office has been opened in the Camp de Vincennes.

THE MEDITERRANEAN SQUADRON.—A correspondent, writing from Malta, under date Sept. 21, says: "H.M.S. ship 'Alexandra,' with Admiral Lord John Hay on board, accompanied by the 'Superb,' 'Dreadnought,' and three first-class torpedo boats, left the harbour on Tuesday last for a cruise. A night attack was made on the 'Alexandra' when anchored in the Comino Channel by the other ships and the torpedo boats, three second-class ones belonging to the 'Superb' and 'Dreadnought' being also hoisted out for the occasion. The attacking vessels left St. Paul's Bay at seven o'clock in the evening, and with the boats in company steamed slowly round to where the 'Alexandra' was supposed to be. At nine o'clock all lights on board the ships and boats were extinguished, and they were cleared for action. A rocket from the 'Superb,' about half an hour later, was the signal that the flagship was discovered, and the engagement soon became general, lasting half an hour. One torpedo boat came to grief during the attack, as, blinded by the electric search-lights of the vessels, she was run ashore with the loss of her propeller and damage to her plates. She was towed into harbour next morning by the 'Superb.'"

A MODIFICATION IN THE BRUSH ARC LAMP.—Amongst the distinguishing features which separate the dynamos and lamps of the Brush system from those of its many competitors, one of the most striking is the constancy of type which marks them. During the seven years of their existence both dynamos and lamps have naturally been modified and improved in various ways. The improvements effected have been those of detail, gradually introduced, and in every case the modification entailed has been one that has been easily and cheaply grafted on to the original pattern. Amongst these may be instanced the new laminated armature, which, although it increased the output of the Brush machine by 50 per cent., yet did not entail any alteration in or even removal of the machine frame, and enabled the earlier solid form, whose place it took, to be kept as a reserve in cases of emergency. So with the Brush lamp, which is one of the few lamps which can be relied on to work continuously without getting out of order. The object has been always to avoid any kind of addition to the working parts, its hardiness and endurance far outweighing, in the opinion of some practical men, any slight inconvenience from occasional flickering. Recent experiments in another direction have, however, shown that without any such addition to the working parts, but simply by a modification in the winding, the slight unsteadiness referred to may be effectually removed.

"ELECTRIC LIGHTING AND THE LAW."—This was the title of a paper read before Section G at the British Association meeting. The paper was merely a diatribe against the Electric Lighting Act, and contained no new argument or any old arguments in a new light. It was useful, however, in that it recalled attention to a subject which is not yet settled. The value of any changes made in the Act and what the effect will be upon the electric light industry are questions for the future, while it may even now be disputed whether progress is as slow as is supposed. The field is not vacant—it is already occupied ; and the capital expended upon existing illuminants will not be shunted because a new and better illuminant is in the market. Railways did not replace coaches in a year, nor should it have been expected that the introduction of the electric light would differ materially from the introduction of other improvements. We have never looked upon the Act as altogether useless—rather in the shape of a violent medicine, which had the effect of bringing many men to their senses. The existing caution of investors is not favourable to specu-

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lators and swindlers, but it leads to a closer examination of evidence; it will lead to a calmer spirit of investment rather than the feverish spirit of speculation. The time was not ripe for combined street and house lighting in 1882, nor we fancy is it now upon a very large scale. Better to walk first and run afterwards than to begin by galloping.

AN ELECTRO-MECHANICAL CLOCK.—An electro-mechanical clock is being exhibited by Mr. B. Watkins, of Leadenhall Buildings. It is apparently of an ingenious and simple mechanism, winding itself automatically, and maintaining a continuous action from year to year. It is said to require a small spring but little larger than the main-spring of a watch, which is kept at a uniform tension, and acts directly on the hour-wheel. This spring is wound in six seconds, and offers no interruption to the time while winding. It is kept only at a tension sufficient to run the clock one hour. It is then wound again by means of a small rotary electric motor, which is connected with the mechanism. An ordinary battery is concealed in the frame or case of the clock, and has, it is claimed, sufficient power to wind the clock two years without attention. The hour wheel, each hour of its revolution, switches the electric current through the motor, which rapidly revolves for six seconds, and communicates its rotary motion, by a gear-wheel, to the barrel on the centre arbour containing the spring. This barrel (in one revolution) imparts sufficient tension to the spring to run the clock one hour, stops the motor by breaking the electric current, and the battery rests for an hour, or until it is necessary to wind the clock again. This process is automatic and continuous from year to year, and the battery is used six seconds each hour, or less than fifteen hours in a year. The inventor is Mr. C. H. Pond, of New York.

THE COST OF OVERHEAD WIRES.—Mr. David Brooks, in a letter to one of the American papers, makes the following calculation with regard to the cost of overhead wires in Philadelphia:—"On September 22nd, 1884, the total number of miles of overhead wire, as reported to the city authorities, was something short of 4,000 miles, and this embraced the whole city. This sum is that reported by the different companies and the owners of private lines. It is presumed that it falls short of the actual amount, inasmuch as these reports were made up for the purpose of taxation, of which they got clear. But say there are 4,000 miles within the thickly built-up portions of the city, and that 80 dols. per mile would be required for putting them under ground, the cost would be 320,000 dols., and the interest on this sum at 6 per cent is 19,200 dols. Dr. Jacques states that not a repairman is employed by the Paris Telephone Company. There are at least one hundred employed in this city. Say that there are fifty for the thickly built-up portions before mentioned at 2·50 dols. per day, this is one hundred and twenty-five dollars per day, and counting three hundred working days in the year, there are 37,500 dols. for wages alone, not counting the expense of poles, wires, house-top fixtures, insulators, &c., and this sum for repairmen is the interest upon 625,000 dols. at 6 per cent. These figures and suggestions are made for the benefit of the overhead wire people, and I ask them if Mr. Preece has not reason to say: 'Why you have neglected this matter so long I cannot make out.'"

THE DESIRE TO BELIEVE.—An author—now, alas, too much neglected—wrote of criticism in this strain: "Grant me patience, just Heaven! Of all the cants which are canted in this canting world, though the cant of hypocrites may be the worst, the cant of criticism is the most tormenting." Sterne was not a reader of the papers devoted to the gas interests, or he would probably have written differently. From the birth of the electric lighting era till now the *Journal of Gas Lighting* has consistently and persistently traduced statements made about electrical progress. Such a policy serves no interest, but on the contrary, creates a feeling of unrest in the minds of gas shareholders that, while ostensibly ridiculing the progress of electricity, there exists in the minds of these writers a real undercurrent of fear that there is danger ahead. Our contemporary will do well to study facts, and ascertain whether gas in the first four years of its history made the real progress that electricity has done during the last four years. Is it, as the journal says, "romance" that electric lighting is making great and successful strides? We are of opinion that there is little of the romantic in the matter, and that such a statement is a plain unvarnished truth. It may justly be argued, however, that electric lighting has not yet had four years of life. Its capabilities were shown at Paris in 1881, and afterwards at the Crystal Palace, and it was not till the close of that Exhibition that any real work in electric lighting commenced. All prior work had been more or less tentative, and principally of the nature of an advertisement. Much, indeed, of the later work has been of the same character, but any statement that electric lighting is not making great strides is false.

THE AMERICAN ASSOCIATION.—It is quite evident that peripatetic science does not flourish in America as it does in England, for while the B.A. meeting had a plethora of papers, its American *confrère* had too few. So far as reports have reached us the electrical papers were not important. Our American contemporary, *Science*, says Prof. H. S. Carhart presented a paper "On Surface Transmission of Electrical Discharges," which was an ingenious revision of work by Prof. Henry. Prof. E. L. Nichols presented some further notes "On the Chemical Behaviour of Magnetic Iron," a continuation of work described at the Philadelphia meeting. Prof. Mendenhall called attention to the modifications and improvements already made or desired in electrometers, especially with reference to their use in observations on atmospheric electricity. Observations of this kind have been regularly made for the last year or two, but the meaning of the variations recorded is still a mystery. Prof. Dolbear read three papers. In one he described a method of studying the contact theory of electricity by means of the telephone. He has found that a click is produced in the telephone every time the circuit is broken between two heterogeneous materials, as copper and zinc. In a second paper he referred to the success obtained in using a Bernstein incandescent lamp for projection purposes; and in the third he described a new battery of high E.M.F. and great constancy, consisting of carbon in a saturated solution of bichromate of potash and sulphuric acid, and zinc in a saturated solution of ammonia chloride; nitric acid can be used instead of sulphuric. Mr. A. T. Rogers read a paper "On the Electrolysis of the Salts of the Alkaline Earths." Two papers by Dr. J. W. Moore were devoted to an "Explanation of Apparatus for Class Room Demonstration of Electrodynamic Phenomena."

THE TELPHERAGE SYSTEM.—A telpher line is to be opened at Glynde on the 10th inst. In view of this fact it may be interesting to glance at the general objects of the telpherage system and the advantages claimed for it by its promoters. The object of the invention, as is now well known, is to convey goods easily divisible into parcels of from 2cwt. to 5cwt., at a speed of about five miles per hour, and at a cost greatly less than that of cartage. It will probably find its application in all cases where the traffic is sufficient to pay interest on a small

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outlay, and is insufficient to pay for the construction of even the cheapest form of railway. The road and trucks closely resemble the road and trucks already employed for overhead wire rope tramways; but instead of dragging the trains along by means of a wire rope, they are driven by very simple electrical arrangements. By employing electricity the following advantages are gained:—The road is simpler and cheaper, as there are no pulleys or working parts, and no second rope is required; the maintenance is cheaper; there is nothing to oil, and no working parts to wear out; the direction of the electrical road can be changed as often as is desirable, so as to follow a winding direction, an object difficult of attainment even to a moderate extent with rope haulage; the gradients in the electrical road may be as heavy as one in eight, and these gradients may vary as frequently as is desired, which is not possible, except with complicated arrangements, in rope haulage; finally, the power required will be less, except in the simplest cases of rope haulage. As compared with light steam railways, the telpher lines may be said to possess the following advantages:—They are cheaper, requiring less metal than the lightest rails. No earthworks, bridges, culverts, drains, or fences are required. No land need be purchased. Much sharper curves can be employed. No attendant is required to accompany the trains; while telpher lines crossing a farm will not materially interfere with the cultivation of the land.

Domestic Lighting made Easy.—Our excellent contemporary, the *Spectator*, commenting in a recent issue upon Mr. Preece's paper, "Domestic Electric Lighting," read before the British Association at their late meeting in Aberdeen, says:—"There is no mystery about the electric light, and nothing in its management which an instructed gasfitter could not learn in a month; yet there is nothing in which small experiment is so difficult, or about which it is so hard for ordinary men to get information. If a man with a large house wishes to burn 40 colza lamps, he can learn in five minutes what his expenditure will be; but if he wants 40 electric lights, the only information he can acquire as to his expenditure is a feebly vague statement, which at once, unless he owns Eaton Abbey, induces him to recede. Why should not the exact method and cost and trouble of lighting a house with electricity be made as familiar to the public as similar details about gas lighting, and hundreds of gasfitters be taught carefully all that is needful for that new development of their trade? There is no need to teach them science. They are not to be like Mr. Preece, but like Mr. Preece's gardener, able to go round and set small engines at work, and repair wire fittings in separate and ordinary houses. The companies are too greedy and too pompous, and do not see that if little groups of houses could once be easily supplied by ordinary tradesmen, the demand for the thing they sell would become almost limitless. People would become habituated to their light, and as it is the best and most convenient, would soon be discontented with any other." In the last issue of the *Spectator* the following letter from a correspondent points to a satisfactory solution to the problem of domestic lighting:—"I have read your article on Electric Lighting with interest, and fully agree that the charges of the various companies at present prevent its more general adoption. I wanted an installation of thirty lamps, fifteen or twenty to be in use at once. The lowest estimate I received was over £150. This was, to my mind, too much. I therefore bought a dynamo, lead, lamps, &c., at various places, and put it in myself, following directions I obtained from several books on the subject. It cost me £41 complete, with driving-power and everything. It is now running, and has been running for eight months, with complete success, and has cost me 6d. only in repairs during this time. If companies would charge reasonable sums I am sure they would soon have more work on hand than they could do." We repeat, this gentleman has solved the problem. It only remains now for him to tell us where we can all procure a dynamo, lead, lamps, &c. (does the &c. mean "engine?") at the price he mentions, and we will immediately go and do likewise.

Sixpenny Telegrams.—We cull the following from *The Globe* of last evening:—

You may write them, dear public, in German or Dutch,
In French, or Italian, or Spanish,
In Latin, or English—it don't matter much—
In modern Greek, even, or Danish;
But Cryptographs, Arabic, Hebrew, are barred,
Aramaic and Syriac; likewise
All systems of shorthand—it seems very hard—
And cuneiform characters spikewise.

You cannot make use of Turanian—no,
Its dialects rich are excluded;
Siamese, Polynesian, don't get a show,
Malay must be never obtruded;
Nomadic-tribe languages are all tabooed,
Though people of moves undecided
Are those most addicted to "wiring," and you'd
Have imagined their wants were provided!

A message in Zend you're forbidden to scratch,
To avoid Attic Greek you're requested,
Unless you are willing to have the despatch
Into lengths of five letters digested;
Nay even that solace is out of your reach
If your lettering be not the Roman;
And *this* in a country where freedom of speech
Is the birthright of man and of woman!

Why should strict regulations make *repertoire* scant,
Deny us Phœnican and Finnish?
In the Postal Department it argues a want
Of the latter our scope to diminish;
And are we expected to offer them thanks
For reducing the price to a tanner,
While they meanly object to our writing in Manx,
Or after the Japanese manner?

Nay, rather, let's vote their conditions absurd—
A clumsy and meaningless jingle—
Whereby we are free to count "cannot" one word,
But cannot count "can't" as a single!
I am bound to admit that in "mother-in-law"
They grant us a lavish immunity,
But *that* word conveys the one notion of "jaw,"
And hence its numerical unity.

If you write "N. E. R.," that is reckoned as three,
With an optional "ner;" the beginner
Might haply conjecture the latter to be
The fag-end of "dinner" or "sinner."
But "ner" is entitled to "collar the bun,"
For, to show you its true valuation,
It's classed with those "words of five letters in *un-Intelligible* combination!"

Don't sport your initials, or yield to a taste
For the affix of ordinal numbers,
If you do, many spaces you'll foolishly waste
On a garnish that only encumbers;
Remember that those who are dealing this dole
Are full of economy's rigour,
And even intend to count ½ as a whole
Word, and "0" as a taxable figure!

Oh! do not write "don't," or they'll count it as two,
And don't venture "do not," but win a
Braw Scotian triumph, and dupe of its due
The Telegraph Office with "dinna!"
Ne'er give them a chance for extortion, in fine,
But try to plant thorns in their pillows
By dating your message "Newcastle-on-Tyne,"
Or "Oldham-cum-Newton-le-Willows!"

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ALTERNATING CURRENTS.

BY THOMAS H. BLAKESLEY, M.A., M. INST. C.E.

(Concluded from page 155.)

Upon the Use of the Two-coil Dynamometer with Alternating Currents.

The dynamometer as usually constructed consists of two coils destined to transmit the same current, and for that purpose placed in series with one another by a maker's connection between the end of the first and the beginning of the second. The user of the instrument has access only to the beginning of the first coil and the end of the second. The torsion to be applied to the suspension of the moving coil to bring it into some constant relative attitude towards the other coil (usually but not necessarily the rectangular position) measures with constant current the square of it, with harmonic current the half of the square, where the maximum value of the current gives the denomination to the current. In this sense I have called the function $\frac{I^2}{2}$ of the harmonic current I, the dynamometer reading. But suppose that the employer of a dynamometer has access to the final terminal of the first coil, and to the first terminal of the second coil, as well as to the two usually free terminals; and, further, suppose that he sends one harmonic current through the first coil, and another harmonic current through the second coil, the only ruling condition being that the two currents shall have the same period. What in such a case will be the reading of the instrument? What will be the torsion necessary to bring the coils to the standard relative attitude? It will be as follows: The reading of the dynamometer will measure the quantity $\frac{I_1 I_2}{2} \cos\theta$, when $I_1 I_2$ are the currents as usually defined by their maximum values, and θ is the angle of the phase difference between the currents, *i.e.*, $\theta = \frac{\pi t}{T}$ when t is the interval of time at which the phases of one current follow the same phases of the other.

The truth of this statement appears at once by applying the first geometrical proposition (see first Article), when the two magnitudes there considered represent I_1 I_2 respectively.

I propose to call the reading of a dynamometer under such circumstances the *Force Reading*, and the function $\frac{I_1 I_2}{2} \cos\theta$ will receive the same name. The propriety of this depends upon the instrument being so graduated that when a direct unit current flows in each coil the angle of the index shall be taken as the unit angle.

This is the same condition under which $\frac{I^2}{2}$ is called the dynamometer reading, under the usual circumstances of connection.

The instrument can be converted into a dynamometer of usual construction by placing a stout wire between the final terminal of the first coil and the first terminal of the second, in fact by making a series arrangement of the coils.

It is clear, therefore, that such an instrument is capable of giving in the first and second place the two dynamometer readings of the two currents—viz., $\frac{I_1^2}{2}$ and $\frac{I_2^2}{2}$, and in the third place the force reading, or $\frac{I_1 I_2}{2} \cos\theta$. A comparison of these three readings will therefore furnish the important angle θ, the angle of phase difference, and, by inference, *all the quantities upon which its value depends.*

Let the three readings be a_1 a_2 a_3, so that

$$\frac{I_1^2}{2} = a_1, \quad \frac{I_2^2}{2} = a_2, \quad \frac{I_1 I_2}{2} \cos\theta = a_3$$

$$\therefore I_1^2 I_2^2 = 4 a_1 a_2 \quad \therefore \cos\theta = \frac{a_3}{\sqrt{a_1 a_2}}.$$

The final formula, viz., $\cos\theta = \frac{a_3}{\sqrt{a_1 a_2}}$ will not be changed even if the instrument is not graduated, as I have supposed, but in any uniform manner, including of course the usual degree graduation.

Before proceeding to examine the application of this method to particular cases, it will be well to point out the following peculiarity. Whereas, when a dynamometer is employed to take a *dynamometer reading* the twist to be given to the suspension is always in the *same direction*, still when used for *a force reading* the twist may have to be applied in either direction. This will merely depend upon the value of $\cos\theta$. If in any case the tendency were in the unusual direction, it may be reversed, should the mechanical arrangement of the suspension or the direction of graduation demand it, by simply making the terminals of one of the coils change places with reference to the main circuit.

The previous chapters have been mainly devoted to tracing the effect of self and mutual induction and of condensers, local or distributed, upon the values and phases of the resulting currents of the system. All currents in the systems considered have the same period. If, therefore, in the dynamometer we have an instrument capable of measuring the various currents and of detecting their phase differences, it is clear we possess the means of calculating the values of coefficients of self and mutual induction and the capacities of condensers.

To take as an example the case of a harmonic source of E.M.F. operating in a primary coil, which in its turn acts by induction upon a secondary coil. First, let the dynamometer readings for the two currents be taken separately, and suppose them to be a_1 and a_2 respectively. Then let the force reading be taken, and let it be a_3. Then the cosine of the angle of phase difference will be $\frac{a_3}{\sqrt{a_1 a_2}}$.

But a reference to Fig. 5 shows that this angle is B C F or C E A, whose cotangent is equal to $\frac{L'\pi}{rT}$, L' being the coefficient of self-induction of the secondary coil.

But $$\cot^2\theta = \frac{\cos^2\theta}{1-\cos^2\theta}. \quad \therefore \left(\frac{L'\pi}{rT}\right)^2 = \frac{a_3^2}{a_1 a_2 - a_3^2}$$

$$L' = \frac{rT}{\pi} \frac{a_3}{\sqrt{a_1 a_2 - a_3^2}}.$$

Therefore the coefficient of self-induction of the secondary coil is determined, the period and resistance being of course supposed known.

The value of M, the coefficient of mutual induction, may be found without further observation, thus.

$$\frac{CA}{CE} = \sin\theta \text{ and } \frac{CE}{CF} = \tan CFE = \frac{M\pi}{RT}.$$

Hence $$\frac{CA}{CF} = \frac{M\pi}{RT} \cdot \sin\theta.$$

But $$\frac{CA}{r} = I_2. \quad \therefore CA = r\sqrt{2a_2}.$$

Similarly $$\frac{CF}{R} = I_1. \quad \therefore CF = R\sqrt{2a_1}.$$

Hence $$\frac{r}{R}\sqrt{\frac{a_2}{a_1}} = \sqrt{\frac{a_1 a_2 - a_3^2}{a_1 a_2}} \frac{M\pi}{RT},$$

and therefore $$M = \frac{rT}{\pi} \cdot \frac{a_3}{\sqrt{a_1 a_2 - a_3^2}}.$$

or the coefficient of Mutual Induction is determined.

If the coefficient of self-induction in the primary coil is desired, it may be determined by making it temporarily the secondary coil, and pursuing a similar course to that already described. A second determination of M will result from the second series of observations serving as a check upon the former series.

It may be pointed out in passing that in the determinations of L' and M the resistance R in the primary coil need not be

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known, for its symbol does not occur in the formulæ for those magnitudes. Hence any change in the value of the resistance in the primary coil will not affect the relative values of a_1, a_2, and a_3, upon which M and L′ are calculated, for they are independent of R.

Therefore, the insertion of a resistance in the primary coil may be used to bring all the readings within the range of the instrument, by pairs in turn. Thus, suppose a_1 a_2 a_3 are in descending order of magnitude. It might happen that when the resistance in the primary is such as to allow a_1 to be read, a_3 might be so small as to be untrustworthy. In this case let a_2 be read. Then take resistance out of the primary circuit. All the readings will go up, a_1 would be off the scale at the high end, but a_3 would reach a reasonable value, and may be compared with a_2. Now a_2 will be found to have gone up in a certain proportion. It will now only be necessary to reduce a_3 in this proportion to obtain a value which, with the former values of a_1 and a_2, will serve for immediate use in the equations.

In investigating the capacity of a condenser by means of an alternating current, we may bridge over a circuit by means of the condenser at points dividing the circuit into two portions, r containing the generator, and R beyond the terminals of the condenser. It may be convenient to avoid a coefficient of self-induction in that part which is remote from the generator, a matter easily accomplished. The coefficient for that part which contains the generator cannot in practice be avoided, but fortunately will not appear in the calculations. For a little consideration will show that if there is no coefficient for the remote section the construction of the diagram upon the rules given for Fig. 11 will coincide with those given for Fig. 7 up to and including the construction of the lines giving the effective electromotive forces in the two sections. So that we need contemplate only the construction of Fig. 7.

The procedure will be as follows:—

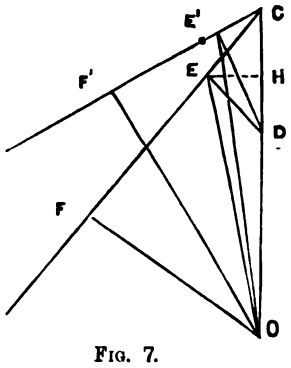

Fig. 7.

(1.) Take the dynamometer readings for the two sections.

Let them be a_1 for the generator's section.
a_2 for the remote section.

(2.) Take the force reading between the two sections.

Let this be a_3.

Then, taking I_1 and I_2 as the currents in the two sections, near and remote, respectively, we must have

$$\frac{OE}{r} = I_1. \quad \therefore \quad OE = r\sqrt{2a_1}.$$

$$\frac{EC}{R} = I_2. \quad \therefore \quad EC = R\sqrt{2a_2},$$

and $\frac{a_3}{\sqrt{a_1 a_2}}$ will be the magnitude of the cosine of the angle C E O, or the sine of the angle D E O.

Now, from the geometry of the figure,

$$\tan^2 OCF = \frac{OF^2}{FC^2} = \frac{OE^2 - FE^2}{FC^2}.$$

But $$FE = \frac{r}{R} EC = r\sqrt{2a_2},$$

and $$FC = \frac{R+r}{R} EC = \overline{R+r}\sqrt{2a_2}.$$

Hence $$\tan^2 OCF = \frac{2r^2 a_1 - 2r^2 a_2}{2\overline{R+r}^2 a_2} = \left(\frac{r}{R+r}\right)^2 \frac{a_1 - a_2}{a_2}.$$

Therefore $$\tan OCF = \frac{r}{R+r}\sqrt{\frac{a_1 - a_2}{a_2}}.$$

But by the construction $$\frac{C\pi Rr}{T\cdot(R+r)} = \tan OCF.$$

Hence $$\frac{C\pi R}{T} = \sqrt{\frac{a_1 - a_2}{a_2}}.$$

or C, the capacity of the condenser, $= \frac{T}{\pi R}\sqrt{\frac{a_1 - a_2}{a_2}}$,

thus determined by the dynamometer observations. It will be noticed that this formula does not involve the force reading a_3, but this if taken can be used in the place of a_2, for the values can be shown to be identical.

To prove this point, consider that F E O is the angle of phase difference; therefore, its cosine is equal to $\frac{a_3}{\sqrt{a_1 a_2}}$. But cos F E O is also equal to $\frac{FE}{EO}$

$$= \frac{ECr}{R}\frac{1}{EO} = \frac{r}{R}\frac{R\sqrt{2a_2}}{r\sqrt{2a_1}} = \sqrt{\frac{a_2}{a_1}}.$$

Hence $$\sqrt{\frac{a_2}{a_1}} = \frac{a_3}{\sqrt{a_1 a_2}},$$

or $$a_2 = a_3.$$

This is an important fact in employing the method to measure a condenser, for in practice it would be desirable to have as little self-induction in the remote section of the coil as possible. In this investigation it has been assumed at zero. But the self-induction in the near section has no effect upon the operations. Hence it would be desirable to have the coil in the remote section of no more than a very few turns of wire, while the sensitiveness of the instrument might be furnished by having very many turns in the other coil; *i.e.*, that in the near section. For the same reason it would be well to make the standard position of the coils the rectangular one.

If it be necessary to take the self-induction of the remote section into consideration, we may contemplate the construction of Fig. 11 down to the fixing of the point O.

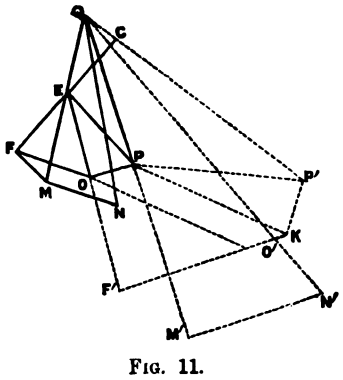

Fig. 11.

In this case the observations may be expected to furnish not only the value C of the capacity of the condenser, but also the value of the coefficient of self-induction of the remote section, as in fact they will be found to do. If a_1 a_2 a_3 are the three observations, we have

$$OE = r\sqrt{2a_1} \quad EC = R\sqrt{2a_2}.$$

$$\therefore \text{ also } EF = r\sqrt{2a_2}, \quad \text{and} \quad \cos FEO = \frac{a_3}{\sqrt{a_1 a_2}}.$$

For brevity call the angle F E O θ, and the angle C E Q β. Then also F E M $= \beta$. Because E M is perpendicular to F O, and

$$EF\cos\beta = EO\cos\overline{\theta - \beta}.$$

$$\therefore \cos\beta = \frac{EO}{EF}\cdot\cos\overline{\theta-\beta} = \sqrt{\frac{a_1}{a_2}}\cos\overline{\theta-\beta}.$$

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Hence $$\tan\beta = \frac{1-\sqrt{\frac{a_1}{a_2}}\cos\theta}{\sqrt{\frac{a}{a_2}}\sin\theta} = \frac{a_2-a_3}{\sqrt{a_1a_2-a_3^2}}.$$

But $$\tan\beta = \frac{L_1\pi}{TR}. \quad \therefore L_1 = \frac{TR}{\pi}\frac{a_2-a_3}{\sqrt{a_1a_2-a_3^2}},$$

or the coefficient of self-induction is determined in terms of the dynamometer observations.

This formula also demonstrates the equality of a_2 and a_3 when there is no self-induction.

To find the capacity. From the above value of tan β we may obtain $$\cos^2\beta = \frac{a_1a_2-a_3^2}{a_2(a_1+a_2-2a_3)}.$$

Further, $$\tan^2 MQN = \frac{MN^2}{QM^2} = \frac{R^2FO^2}{R+r^2QE^2} = \left(\frac{R}{R+r}\right)^2\frac{FO^2}{CE^2}\cos^2\beta$$

$$= \left(\frac{R}{R+r}\right)^2\frac{FE^2+OE^2-2FE.OE.\cos\theta}{CE^2}.\cos^2\beta.$$

$$= \left(\frac{R}{R+r}\right)^2\frac{2r^2a_2+2r^2a_1-4r^2a_3}{2R^2a_2}.\cos^2\beta$$

$$= \left(\frac{r}{R+r}\right)^2\frac{a_1+a_2-2a_3}{a_2}.\frac{a_1a_2-a_3^2}{a_2(a_1+a_2-2a_3)}$$

$$= \left(\frac{r}{R+r}\right)^2\frac{a_1a_2-a_3^2}{a_2^2}.$$

Hence $$\tan MQN = \frac{r}{R+r}.\frac{\sqrt{a_1a_2-a_3^2}}{a_2}.$$

But by construction $$\tan MQN = \frac{C\pi Rr}{TR+r}.$$

Hence $$C\frac{\pi R}{T} = \frac{\sqrt{a_1a_2-a^2}}{a_2}.$$

and $$C = \frac{T}{\pi R}.\frac{\sqrt{a_1a_2-a_3^2}}{a_2}.$$

Hence the capacity is determined in terms of the dynamometer observations.

Similarly, alternating currents and dynamometers may be employed to investigate the rate at which capacity is distributed along a cable.

THE PROPER METHOD OF OBTAINING THE AVERAGE DURATION OF AN INCANDESCENT LAMP.

BY J. A. FLEMING, M.A., D.SC.

Recent statements on the average life of incandescent lamps and other general practice agree in indicating a certain absence of clearness in many minds on the proper principles by which the desired average quantity can be obtained from the experience of observations. It seems desirable, therefore, to call attention to the proper method by which alone any figures at all useful can be obtained. To do this we shall adopt, what is always best when possible, graphic illustrations instead of symbols. Let us suppose that there is an incandescent lighting plant set up for continuous or intermittent use, and that the person in charge desires to arrive at some correct notion as to what is the mean duration of the carbon filament under any condition of working. On a line, $o\,x$, mark off equidistant points, each one of which represents a working lamp. Draw vertical lines through these to represent time or duration, and the crosses represent the times or dates at which lamps are replaced. Thus in the diagram, lamp 2 is replaced at three periods, represented by the crosses a, b, c; the first lamp burnt for a time $2a$, the second for a time $a\,b$, the third for a time $b\,c$, and the fourth lamp is yet burning.

Now, suppose that a trial period of time is taken, represented by the distance between the horizontal lines through A and X. The distance A X represents the duration of this trial run. Suppose it is desired to obtain the average life of the lamps during this period, then the *usual* mode of arriving at this quantity would be to divide the total lamp hours by the number of replaceals, and deduce (perhaps to a decimal) the average life of the lamp. If matters could be so managed that if the lamps all

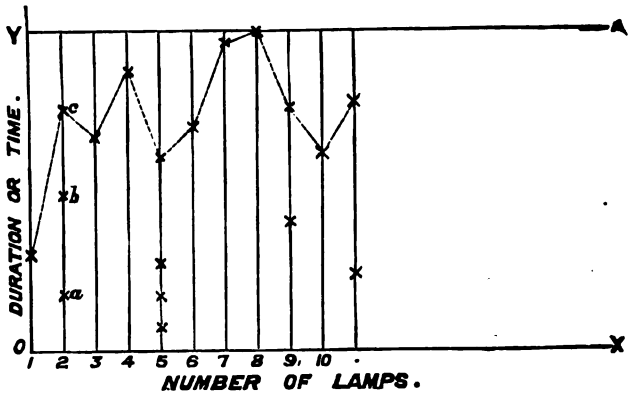

FIG. 1.

gave out at once, and that the trial run finished exactly with the expiry of all lamps, it is obvious that the above mode of procedure would be correct; also, if the lamp hours of every separate lamp were taken from the beginning of the trial up to the end of the duration of a life, the same having been replaced 1, 2, 3 or n times. Then it is also obvious that the average life would be the average of the average deduced by dividing the whole lamp hours of *each* lamp separately by the number of times that lamp has been replaced. But neither of these two processes is practicable in a general way, and accordingly we can deduce no accurate average from any trial in which there remain at the end of the trial unexhaused lives, or lamps which have in them yet lamp hours of potential working. Referring once more to the diagram above, we see that the diagram may be divided into two parts, one above the dotted line formed by joining all the last crosses and one below. The united lengths of all the vertical lives included between the dotted line and the horizontal O X represent the lamp hours of burnt out lamps. The united lengths of all the parts of vertical lines between the dotted line and the upper horizontal A Y represent the lamp hours burnt by lamps yet alive and likely to live.

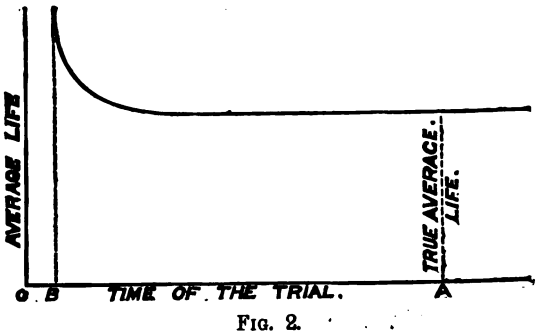

FIG. 2.

Now let us call these two parts the total exhausted lives, and the total unexhausted lives.

If the lamp hours of unexhausted lives form an appreciable or moderate fraction of (much more if it exceeds) the lamp hours of exhausted lives, then the application of the common rule only leads to ridiculous results. And the only circumstances under which the quotient of total lamp hours by replaceals gives a correct approximation to the average life is when the total unexhausted lamp hours is small or negligible in comparison with the total exhausted lamp hours. And under the former supposition the average life is always over-estimated. Accordingly, the moral of this is, no trial tests or experimental

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runs are of the least use for the purpose of averaging the life of incandescent lamps which do not last for a period at least four or five times the average duration of a lamp, that is for 5,000 or 6,000 hours, and the longer the better.

If a given number of lamps be set up and run continuously, and replaced as they fail, and the ordinary rule applied at stated intervals, it would be found that as the trial run extends in time, the average life deduced would diminish towards a fixed minimum, which is the real average.

It is easily seen that the ordinary rule makes the average life of a lamp infinite for short trials, which, as Euclid would have observed, "is absurd."

If we plot down the results of applying the common rule as ordinates along a scale of time representing the time of the trial, then it is easily seen that for time zero, life is infinite; and as the time of the trial increases, we eliminate more and more the respective proportion of unexhausted lives as compared with total lamp hours of exhausted lives, and approximate to a horizontal position in the life curve, which gives the true average life by its distance above the horizontal line. These considerations if weighed will, it is to be hoped, prevent those in charge of installations from rushing into print with statistics derived from one or two hundred hours of burning. Although, as the results of such too limited experience will always be to bring out the average life of the lamp too high, it is, perhaps, hardly likely that lamp manufacturers will refrain from quoting them in their own favour, or come forward to instruct the publisher of them in the true principles which should control the collection of observations intended to furnish an approximate estimate of the mean duration of incandescent lamps properly used.

One further remark suggests itself in connection with the statistics which have given rise to discussion on this subject, and it is this, the vital importance of working all lamps at the proper E.M.F. necessary to make the expenditure of energy in them equal to the proper watt mark of the lamp. And knowing as we do what serious variation is made in the average life by a difference of one or two volts (considered by many of small importance), it is obvious that the careful and systematic use of known accurate voltmeters should be a matter of consideration with every one who has the care of incandescent lighting.

THE LATE MR. JOHN MUIRHEAD.

On Tuesday, September 22nd, the remains of Mr. John Muirhead were interred in the Cemetery of Lower Norwood.

The deceased was in many respects a remarkable man; but such was the quietude and modesty of his character, that few except the members of his own family had any real knowledge of the good and sterling qualities he possessed. Mr. Muirhead was one of the last survivors of the early days of the electric telegraph. He was the colleague and fellow-worker of nearly all the men whose names are indissolubly associated with the introduction of that great invention; and very interesting were his reminiscences of the old times. But he was a man not much given to talking; and most of his recollections have ended with him.

Born at Gifford, in Scotland, in the year 1807, his life has extended over what will probably be considered one of the most progressive periods in the world's history. The more material part of this progression has been the development of the railway and the telegraph; and in the latter of these great works the late Mr. Muirhead played an honourable part.

The electric telegraph, under Cooke and Wheatstone, had begun to take a practical form in this country in the year 1837; but it was struggling with many difficulties. When in 1846 the original Electric Telegraph Company was formed, Mr. Muirhead, who even as a young man showed a decided talent for construction, joined this company, and remained in its service until the system was transferred to the Post Office in 1870. From his first connection with the telegraph until within a few years of his death, Mr. Muirhead devoted himself continuously to the work of extending the system, building the lines, and perfecting the appliances.

The tubular bracket of annealed iron which he introduced in place of the solid cast-iron one previously employed was rapidly adopted, and is now in general use. The hollow iron pole, which under various improvements is now so common, was also, we believe, one of his ideas. The early metropolitan lines were laid by him, and the pneumatic system for collecting messages from the local telegraph stations to the central transmitting station in London and other provincial towns was first installed under his supervision. Mr. Latimer Clark and the late Mr. Cromwell Fleetwood Varley did much to introduce and perfect this novel system of communication, which is now employed in all the important telegraphic centres.

In the absence of manufacturing facilities such as exist now for the supply of telegraphs to the world at large, Mr. Muirhead, in conjunction with Mr. Latimer Clark and Mr. W. M. Warden, of Birmingham, founded the house now known as Messrs. Latimer Clark, Muirhead and Co., a firm which, in the course of its career, has planted the telegraph in every corner of the world, and doubled the carrying power of nearly all the great submarine cables, by the duplex system, which is the invention of Mr. Muirhead's sons. It was from this manufactory that Mr. Muirhead introduced the form of battery which bears his name, a form so eminently portable and practical that it has become the model for most of the existing batteries, while continuing itself to be largely employed. This battery includes the use of rectangular earthenware vessels, containing flat porous pots, the whole being removable from the box for cleaning purposes.

Other improvements and innovations of Mr. Muirhead might be mentioned, such, for example, as the introduction of teak for telegraphic apparatus in hot countries; but the greater part of his time was devoted to the practical execution of telegraphic work. His ordinary duties took him to every part of the country, and left him very little leisure time. Nevertheless, he was a well-read man; and on retiring from business a few years ago, his favourite amusement was reading works of history, a study in which he was extremely well versed. His knowledge of events and their dates was unusually accurate and comprehensive.

Endowed with a very strong and robust frame he hardly knew a day's illness, except at rare intervals when overwork or exposure had told upon his constitution. His natural vigour was sustained by sober habits, both of mind and living.

A few months before his death the health which he had hitherto enjoyed began to break down, and the tranquil leisure he had earned so well was interrupted by a serious illness. He rallied, however, to some extent from this, but on Thursday, the 17th September, while conversing quietly with his doctor in the library of his residence at Oakwood, he suddenly fell back and expired. Thus died a faithful servant; one who had done his work ungrudgingly and taken his reward.

Mr. Muirhead was unquestionably a successful man, and his success was due rather to the influence of character than to the possession of genius. One discerned in him some of the best traits of the old Scottish type—a natural truthfulness and sincerity, intolerant of duplicity and humbug; a plainness of speech for which the times are perhaps a little too fine; a directness of action which led him straight to the end in view. Frugal and industrious he was also economical; but it was the economy of principle and honest independence. He could not be induced to do an unscrupulous action in order to profit by it. He did the thing which he believed to be right, and left the consequences to be dealt with when the time came. Mr. Muirhead always took a great interest in his work. He loved good material to work with, and took a pride in turning out a piece of thorough workmanship. If one of his men was doing a job in a slovenly or clumsy fashion he would take the tool out of the man's hands and show him how it should be done. The workmen liked and respected him because of his practical knowledge of the business and his kindly interest in them and their affairs. His very presence in the shop was sufficient to make the work go on with diligence. If he had occasion to rebuke a workman he did so privately, and not before his fellows in a way calculated to pain the man's self-respect. He forebore to scold or brow-beat him, and imposed no fines. His method was to point out the faults of the work, and appeal to the better nature of the man for an improvement in it. Under a somewhat rugged exterior he concealed a warm and kindly heart. But such was his dislike of anything approaching to ostentation that most of his benevolence was strictly private, and perhaps only known to the recipient. He had a sympathy with struggling men, especially artisans, and enjoyed giving them a helping hand in his own works. Some of these turned out badly, others well, and a few have even become notable. He believed firmly in education for the masses. A good education, he was wont to say, is much better than money; a man cannot spend it. He was also very tolerant of the opinions of other persons in political and religious matters, believing that they held them in perfect honesty, and considering that they had as much right to their opinions as he had to his own.

Living an upright and faithful life, he has left few or no enemies behind him. He was one of those who never sought to shine, and most of his work was of that silent order which is its own praise. He was one of the labourers who seek to do with all their might the work that is put into their hands.

"Without them, how could laws or art
Or towered cities rise?"

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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EDUCATION AND EXAMINATION.

Next to the Presidential Address in general interest, and before it perhaps in practical utility, was the paper read by Prof. Chrystal to the Mathematical and Physical Section of the British Association, on the Diffusion of Scientific Knowledge. So far as title goes, there was a close correspondence between this and the subject chosen by Dr. Playfair; but in treatment they widely differed. The President's method of diffusing scientific knowledge would be, as we pointed out at the time, to bribe the people with a subsidy out of the public exchequer, and so virtually to convert Science into a State Establishment. Prof. Chrystal has no such suggestion or any other for diffusing science knowledge; his complaint is rather that it is too much diffused already—diffused, in fact, to such an extent that he finds it hard to discover substantial trace of it. Of crammers' knowledge there is an abundance, and of text-books adapted to the crammed no lack; of examinations, too, which incontestibly prove the universal prevalence of knowledge thus diffused, there is more than enough; but as evidence of the spread of scientific knowledge, which is not the same thing as a knowledge of science, Prof. Chrystal cannot accept these signs without misgiving—nay, speaking as an examiner as well as teacher, he roundly asserts that the net result of modern scientific teaching is the filling up of examination papers with lifeless words reproduced from dead text-books. By dead the worthy Professor does not mean that they are out of date—on the contrary, they are in this respect very much alive—but they are stuffed with inanimate fragments unfit for wholesome food, and are good for nothing but the show case. All men practically engaged in teaching, says Prof. Chrystal, are agreed that it is the absurd prominence given to written competitive examinations that works all the mischief. Yet this competitive examination system is primarily due to the State's interference, and is mainly fostered by its patronage. A more damaging commentary upon Dr. Playfair's Presidential Address could hardly he imagined.

The condition into which the educational system is drifting, and more especially the scientific portion—which is peculiarly adapted for the crammer's methods—is graphically set forth in a single passage of Prof. Chrystal's discourse. It is now argued, he alleges, that professional lectures should contain nothing but what is to be found in every text-book; lectures are therefore superfluous; examinations should touch nothing that is not in the text-books, because that would be unfair; and similarly there should be nothing in the text-books not likely to be set in examination, because that would tax the candidate's memory unnecessarily. For our part we see nothing surprising in this description; it is the natural and logical outcome of a system which has grown up for many years under our very noses, with our eyes wide open, with consequences predicted over and over again, and with results which obtrude themselves upon us at every turn. The end of all education having been to fit the pupils to be examined, and the end of every examination to pass a goodly number of badly taught pupils, it is no marvel that both educators and educated "are left more and more to wander in primeval darkness." It may be true that specialists, into whose hands true science has exclusively fallen, are "soaring higher and higher into the light of day." But if so the fact is phenomenal; the tendency is to stop their flight, to tie them down to the level of competitive exams, and to entice them with the rewards of successful passes. In a few years' time we may hope to have achieved for English learning what the Chinese long ago accomplished for theirs. In China the competitive examination has prevailed in every branch of life for centuries; and unless they are greatly maligned the Chinese are at once the most ingenious liars and most learned idiots the world has ever seen. The excuse of the English teacher, otherwise honest and well meaning, is, says Prof. Chrystal, that he does so and so, knowing it to be vicious, "because of the examination." No Heathen Chinee could wish for a better excuse.

It is here, when we approach the moral aspect of the subject, letting alone its practical aspect, that we feel disappointed with Prof. Chrystal's otherwise sensible address. The description he gives us of that solemn, national farce, a great public competitive examination and its ridiculously misleading results, would, one might suppose, arouse some indignation, some stern resolve to remedy the evil, or—well, let us say, turn specialist, soaring "higher and higher," though the pay may be lower and lower. But we are rather asked to pardon the system, chiefly because it is an outlet from the old one of patronage; as if patronage ever wrought such mischief as this is doing. Patronage had always the strongest motive for patronising the best available material, and at its worst it never systematically pretended to be what it was not. Prof. Chrystal says that the cure for all this evil—the evil of pretending to be educating when we are only examining—is "simply to give effect to a higher ideal of education in general, and of scientific education in particular." Our own view, we feel constrained to say, is, that to give effect to a high ideal you must first have a high ideal of moral duty in general, and that of scientific men in particular. They still enjoy in the non-scientific world the reputation for self-denying integrity in the pursuit of their calling; yet here we have a

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confessedly vicious and abortive system carried on by them, under the guise of education, costing the country a vast deal of money, which is pocketed chiefly by scientific men, and which they admit might just as well be thrown in the school fire for all the good it does. They have had this system virtually under their control for more than a generation past, and they are almost the only people who profit by it. If not to them, to whom are we to look for a remedy? But we do not discover one in Prof. Chrystal's paper, nor is it inspired with anything more energetic than the plaintive wail of well-deserved failure. The most vigorous attacks on the system in recent times, so far as our memory serves, have come from quite another class—from journalists and men of letters. It is time that men of science bestirred themselves to remove this discreditable sham—the parent of many other shams in the sphere of scientific education—and although the task may not be easy it is in one sense simple. Let them unite in protesting against it under threat of washing their hands of the business altogether. But to do this effectually they must first disabuse their minds of the prevailing delusion that any good can come of diffusing knowledge that is only coveted for the sake of a pass. It would be much nearer the truth to say that nobody is worth teaching who does not love to learn.

SIXPENNY TELEGRAM DAY.

From all accounts received to the time of our going to press, the first day of the Sixpenny Telegram era passed off very satisfactorily. By this we mean there was no untoward rush, no panic, and no pressure which the telegraph service was not quite competent to deal with in a satisfactory way and without unusual delay. A considerable extra force of telegraphists, and of course a very large increase in the number of messengers, were provided at most of the head offices; but so far as the former is concerned there was no urgent need for them, as the traffic on the whole, although vastly increased in point of numbers, was far from being proportionately augmented in bulk. It is calculated that there has been an increase of fifty per cent. in the number of messages, but this of course is largely conjectural; whereas the decrease in the length of the messages is represented by the fact that forty per cent. of the traffic passing through the principal centres consisted of messages containing not more than twelve words each. If this percentage is maintained throughout the country, conclusive proof will be afforded that the cutting down of the maximum number of words by more than fifty per cent. has been attended with no public inconvenience. The new tariff is so low that if nearly half the messages can be compressed within the twelve words' limit, there need be no hesitation about taxing the rest.

As regards the great Central Telegraph Station in London, thanks to the admirable provisions made by Mr. Fischer, the Controller, and his excellent staff of assistants, the first day's business was disposed of with the customary smoothness and celerity; and a visitor to the gallery could mark no perceptible change in the aspect of affairs, except perhaps that both male and female operators were in stronger force than usual. We were informed that although the addresses have experienced a curtailment amounting to forty or fifty per cent., no inconvenience has yet arisen with regard to the deliveries. This matter, however, has been greatly facilitated, no doubt, by the registration of addresses, which has latterly gone on at the rate of some hundreds daily in anticipation of the reduced limit. Perhaps the most notable effect of the new tariff was felt in the metropolitan part of the establishment, where the number of local messages was immensely greater than usual. No small proportion of these, however, were of the facetious character peculiar to such inaugurations. The honour of first place was obtained, we are told, by one of these, sent by some midnight prowler, who relieved his feelings at the small cost of sixpence by telegraphing from one part of London to another that it was "all on account of Eliza." Another telegram of a more practical kind, to improve the occasion, was forwarded by the clerks of a provincial office to the Postmaster-General wishing success to the Sixpenny Telegram scheme, *and* payment for Sunday duty. We hope they may have their reward.

CORRESPONDENCE.

THE PNEUMATIC SYSTEM FOR TELEGRAPH PURPOSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the interesting description of the pneumatic system which was read at the British Association, and which appears in your journal of yesterday, it is stated that "the system was first introduced by Mr. L. Clark in 1854, who employed vacuum;" and, later on, "about the year 1866 Mr. C. F. Varley applied compressed air for propelling the carriers in the opposite direction," &c. These statements are perfectly correct, and they appear in almost all descriptions of the pneumatic system, but they would seem to imply that Mr. Varley first suggested the use of both pressure and vacuum, which is not the case. The fact is that, succeeding me in the position of engineer to the company, it was only in his day that the company's requirements were such as to justify the expense of a double system of engines and pumps.

A single extract from my patent, No. 1,641 of 1857 (nine years before Mr. Varley's application of the system) will be sufficient to show this:—"In working telegraphs of this description I have found that a saving of cost may be effected by so arranging the apparatus that the packages are propelled in one direction by exhausting the air from the pipe in front of the package, and in the other direction by admitting behind it air under a pressure exceeding that of the atmosphere. When the apparatus is arranged in this way one pumping engine only is necessary, and this engine works to produce a partial vacuum in one vessel and a pressure in another vessel."

The constant association of Mr. Varley's name in connection with the application of the double system conveys the idea that I had overlooked so obvious an employment of pneumatic pressure. So far as I am aware the only real advance made upon the system since I left it is the introduction of the "Pneumatic double sluice valve," described in Mr. Willmot's paper, which is an admirable invention and appears to act most efficiently.—Yours, &c., LATIMER CLARK.

6, Westminster-chambers, Victoria-street,
London, 26th September, 1885.

A PHENOMENON OF CURRENT INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you allow me the privilege of your space to bring the following phenomenon under the notice of electricians—though I ask this with the consciousness, first, that the phenomenon may possibly be already known; and, secondly, that it may be a phenomenon not of induction generally, but merely due to some defect in the instrument I was using at the time, though I do not think this was the case?

Whilst engaged with a small induction coil six or seven inches long, with a spring make-and-break, I noticed, as often as I completed the secondary circuit, that the humming note caused by the vibrations of the spring rose somewhat in pitch, remaining constant at that pitch as long as the secondary current continued to be closed, and falling again to the lower pitch when an interruption was made. My chain of inferences drawn from the result was as follows:—The

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higher pitch, or increased frequency of vibrations in the spring, means increase of magnetism; and increase of magnetism means increase of current in the primary coil, an effect of completing the secondary circuit. In this way I was led to think that completing the secondary circuit *relieved* the primary coil. But let me hear what others say who have had a wider experience in the matter before I develop any private explanations, which might be very wide of the mark. I will only add that those who wish to investigate the *fact* must either have or borrow a good musical ear, or, still better, a registering instrument. It is not difficult to anticipate that different varieties of pitch for the closed circuit might be attained by varying the resistance of the secondary circuit externally.—Yours, &c., E. ALDRED WILLIAMS.

37, Burlington-road, W., Sept. 28, 1885.

A SELENIUM PHOTOMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In his lecture on the "Electric Light and Atmospheric Absorption," Prof. Adams stated that "selenium gives a very delicate mode of *measuring* the illuminating power or the energy of the visible radiations by the increase in the electric current, as shown by the deflection of the galvanometer." He exhibited among others a selenium cell received from Mr. Fritts, of New York, the resistance of which was reduced from 75,000 ohms on exposure to one candle at a distance of one foot, and he then said that "in this change of 32,000 ohms for an illumination of one candle we see that we have a means of *measuring* very small differences of illuminating power, and therefore a means specially adapted to measure small differences due to absorption of light by the earth's atmosphere." In the year 1876 I made many attempts to construct a selenium photometer, but I had to give it up because I could not construct or procure a selenium cell which possessed the two qualities which are essential in a measuring photometer, viz., constancy in its resistance when illuminated, and when illuminated the exhibition of a diminution of its resistance accurately proportional to the variation in the illumination. Since then I have carefully studied all the published accounts of experiments with selenium in the hope of finding that this difficulty had been overcome; but, as far as I am aware, no experimenter has yet succeeded in constructing a selenium cell which fulfils these requirements. The experiments of such careful observers as Siemens, Graham Bell, Shelford Bidwell, and others, all indicate that a selenium cell is very unstable and variable in its behaviour, and therefore the more fact that a particular cell exhibits an enormous diminution in its resistance or illumination by one candle, if not supplemented by conclusive evidence that it possesses the other requisite qualities, does not warrant the conclusion that such a cell could be employed as a delicate measuring photometer. If these cells possess these qualities, then I think an account of them would be as interesting to many of your readers as it certainly would to—Yours, &c., R. E. DAY.

48, Belsize-square, N.W.

CONSTANT GRAVITATIONAL INSTRUMENTS

FOR MEASURING ELECTRIC CURRENTS AND POTENTIALS*.

BY SIR WILLIAM THOMSON.

The instruments, the author stated, were parts of two series of electrical measuring instruments, for current and potential, which he was now working out. In the two current instruments—the milliamperemeter and the hecto-amperemeter—the mode of effecting the measurement was founded on Faraday's law that a ferro-magnetic mass placed in a variable magnetic field experiences forces tending to make it move from places of weaker to places of stronger force. The essential parts of the milliamperemeter are shown in the sketch diagram (Fig. 1). It consists of an electro-magnetic coil, fixed with its axis vertical, and a little bar of soft iron hung from one end of a light balanced lever so as to be free to move up and down in a circular arc, deviating but little in its middle and at its two ends from the axis of the coil.

The measurement is given by the deflections indicated on a scale by the end of the balanced lever when a weight of known amount is hung on the ring below the iron mass. To screen the iron from the effects of the earth's magnetism the coil is enclosed in an iron box. In the hecto-amperemeter the variable magnetic field is obtained by a suitable disposition of the metallic conductor conveying the current to be measured.

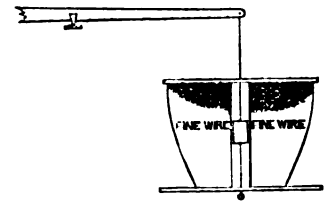

FIG. 1.

The conductor may be taken as consisting of two thick copper plates shaped according to the sketch Fig. 2, supported in a vertical position parallel to each other, say one centimetre apart, and metallically connected at the place indicated by B; A is fixed at a suitable electrode. The course of the current is therefore from A to B, and from B through the other plate to the part of it corresponding to A, which forms the other electrode. In this way two similar varying magnetic fields are produced, and the balanced lever, capable of motion in a plane situated midway between the plates, carries two masses of iron, one in each field. In other respects the instrument is similar to the milliamperemeter.

The electrometer consists of an air condenser with one of its plates capable of a to-and-fro motion so as to vary the capacity of the condenser.

The fixed brass plates are supported so as to be accurately parallel to each other and in metallic connection, while they are thoroughly insulated from the case of the instrument. The movable plate is of aluminium, of the shape shown at B B of the accompanying sketch, and is supported in a vertical position on a knife edge, the plane of its motion being parallel to the fixed plates and situated midway between them. The upper end of this movable plate has a fine prolongation which serves as a pointer for indicating the deflections on the scale of the instrument, and at its lower end is fixed a knife edge having its length perpendicular to the plane in which the plate moves.

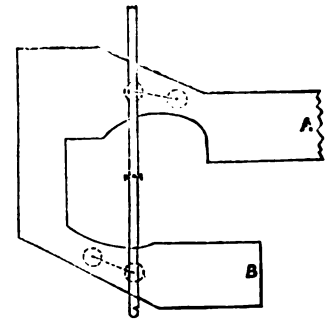

FIG. 2.

When the fixed and movable plates are connected respectively to two points of an electric circuit, between which there exists a difference of potential, the movable plate tends to move so as to augment the electrostatic capacity of the instrument, and the magnitude of the force concerned in any case is proportional to the square of the difference of potential by which it is produced. In the use of the instrument this force of attraction is balanced by the horizontal component of a weight of any convenient amount hung on the knife edge at the bottom of the movable plate.

* Abstract of a paper read at the British Association meeting at Aberdeen.

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AN ELECTRIC SAFETY LAMP FOR MINERS.*

BY F. WILSON SWAN, M.A.

I wish to bring under the notice of the Section the latest result of an attempt to adapt electric light to the requirements of coal mining. The object is to obtain greater security from the danger of the lamp causing an explosion of fire-damp. The principle of the Davy lamp is no doubt very beautiful, and I am not prepared to say that that principle, applied as it is with great ingenuity of detail in the construction of the modern safety lamp, is incapable of giving safety under the ordinary normal conditions of coal mining; but I do say that a well grounded doubt and suspicion rests upon lamps of this class when placed under certain exceptional but not improbable conditions. So long as the lamp, be it the Davy, the Clanny, the Geordy, the Mueseler, or any of the newer designs, is not subject to a strong gust or abnormally swift current of inflammable gas, it is, if well made, probably quite safe even in a highly explosive atmosphere; but it is more than doubtful if the best of these lamps is safe in such an atmosphere in a state of abnormally rapid motion, or when subject to a rush of air, such as a blast or the accidental swing of a lamp may occasion. The fragile partition of wire gauze which alone presents a barrier to the passage of flame from the lighted wick inside the lamp to an explosive mixture of gas outside is too slight a defence against the danger of explosion. The widely-entertained belief that a certain degree of danger is inseparable from the employment in fiery mines of this species of lamp, has naturally led to the inquiry whether it is not possible to get absolute immunity from the danger I have described by resorting to a different principle of construction.

When it was demonstrated that a small and steady light could be produced in a completely enclosed glass bulb by means of the incandescent electric lamp, imagination instinctively turned to electricity as the agent through which complete safety might be secured. The essential fitness of such a light, totally isolated by a gas-impervious covering from the smallest contact with the outer air, was obvious, and indeed it seemed at the first blush of the matter, and in the enthusiasm born of a new invention, that the problem was already completely solved. No sooner, however, was the attempt made to realise this attractive idea than many difficulties presented themselves, and these, on close encounter, proved to be so serious, that what at first seemed easy of accomplishment, began to wear the aspect of total impracticability. One of the chief difficulties was to bring the lamp, and the power to light it, within the limits of portability. The first electric safety lamp evaded this difficulty by requiring that there should be a general source of current supply, from which, by means of strong flexible conducting cords extending between the lamps and fixed main wires, a great number of lamps could be fed. Here is a lamp such as would be used under those circumstances, and which has been used, to a small extent, in one or two pits. It consists of a bell of strong glass defended by a cage of wires enclosing a small incandescent lamp. The connection of the lamp with the flexible conductor is so arranged that the enclosure is completely air-tight.

It is obvious that this kind of lamp, whether fixed or tethered by a flexible conductor, does not meet all the requirements of coal mine lighting. The passages can, perhaps, to some extent, be lighted by fixed lamps of this type, and some of the workings by movable lamps—that is, movable to a limited extent, through their connection with the fixed main wires by flexible conductors. But the cost of such a system of partial lighting by electricity would be great. The electric mains would be difficult to maintain in the presence of frequent stone falls and other inevitable accidents, and there would be great waste of light if the system were thoroughly carried out to the exclusion of detached hand-lamps, because it would be necessary to constantly light many passages in which there was little traffic. A hand-lamp, detached and portable—more or less like the ordinary safety lamp—is therefore an absolute necessity. It is a lamp of this kind that I have striven to put into a practical form, and am about to show you. It consists of two parts, the lamp proper and the battery. The great difficulty was to make the battery small enough and light enough. But these requirements were complicated with others equally imperative. The battery must not be too expensive either to make or to charge. The last-named considerations excluded some combinations, which, in point of bulk and lightness, might perhaps have had advantages over the kind of battery I have chosen to adopt. The trouble and cost of every day emptying, refilling, and generally keeping in order several hundred cells of even the simplest and least troublesome of any known type of *primary* cell appeared to me to put that class entirely out of the question. I was thus forced to consider whether any form of *secondary* cell which would not require emptying and refilling could be so constructed as to meet the necessities of the case. It seemed to me possible, without excessive trouble or expense of any kind, to charge several hundred *secondary* cells by day. This presented little or no difficulty; but to reduce within practical bounds the bulk and weight of a battery of this kind, possessing sufficient power to maintain the necessary amount of light during the required length of time, was a thing by no means easy of accomplishment.

I found by comparing the weight and storage capacity of the most efficient of secondary combinations, namely, the spongy lead and lead oxide combination, which, fundamentally, is that of Planté, that I must be content with a moderate amount of light—with a candle or even less, and the lamp must be so made as to give this light with few cells and small current. By the help of a new kind of filament of exceeding fineness, and at the same time of great strength, I have obtained a lamp which probably requires less current than any lamp hitherto made, viz., ·14 of an ampere. With this current, and an electromotive force of about 12 to 13 volts, the light of half a standard candle is produced; and the energy necessary to sustain this small amount of power during ten or twelve hours can be stored in a set of cells neither too bulky nor too heavy for easy carriage in one hand. Here is the combined apparatus of battery and lamp. Its weight is 6¼lbs., the cylindrical case containing the cells measures 8 by 4 inches. Each of the seven cells composing the battery is constructed in this way:—The core is a lead wire surrounded by peroxide of lead. This is covered by a wrapping of cloth, outside which, and filling the space between the oxide cylinder and the interior lead lining of the containing tube, is a packing of lead filament—a beautiful material invented and manufactured by Mr. Cookson, of Newcastle. The lead filament is in contact with the lead lining, and that, with a strip of lead which forms one of the outward conductors, the lead wire forming the core of the oxide cylinder being the other conductor. The electrolyte is as usual dilute sulphuric acid; adhesion to the lead filament prevents the liquid from spilling if the battery is inclined to one side. The terminals are attached to two elastic strips of brass, and these hold the little lamp between them with a slight end pressure, and in such a simple manner that it is removable in a moment. The lamp is protected against external injury by a very thick glass bull's-eye, and light is economised by a silver reflector behind the lamp. Two sockets within the case provide the means of connecting the battery terminals with the charging circuit. There is also a switch of simple construction which enables the current to be turned off or on the lamp; the object of this is to avoid waste of current by keeping the circuit uncompleted until light is required. Contact is made and broken within a small cavity in the switch plate containing a single drop of oil. Even without this precaution, there is not the slightest danger of ignition of explosive gas by a spark produced at the switch on opening the circuit. The spark, on breaking the circuit, is exceedingly minute, so minute, indeed, as to be quite invisible to the naked eye; even in absolute darkness the aid of a lens is required to see it. But, as I have explained, the switch is so arranged that in turning the current off the lamp this minute, invisible spark will not be produced in contact with the atmosphere, but within a covering of oil, or rather there will be no spark, for it will be entirely suppressed. The switch

* Paper communicated to the Aberdeen Meeting of the British Association, September, 1885.

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is perhaps a superfluous appendage, for if electric lamps were regularly used in a colliery they would be on the charging circuit until required for use, and might remain lighted until put on the charging circuit again. After charging the cells the lid, which has attached to it a carrying handle, is screwed on and locked in the usual way, and then there is no access to the battery without uulocking. A battery of this size, having an aggregate weight of nearly 5½lb., will yield a current of nearly ·14 of an ampere during 12 hours, with an average available potential of about 12 volts. There is a slight gradual fall of potential, the result of which is that the lamp is a little brighter when first lighted than after it has remained lighted some hours. I do not venture to count upon a greater amount of light from this current and potential than half a standard candle.

By reducing the time of lighting to eight hours, the current may be increased to $\frac{2}{10}$ths of an ampere, and with this current, $\frac{3}{4}$ of a standard candle can be obtained without raising the filament to too high a temperature, and, of course, by increasing the size and weight of the cells, still more light can be had. The arrangement for charging, say five hundred lamps, would neither be complicated nor costly. A dynamo of very moderate size, absorbing three to four horse-power, would be sufficient. The cells would be ranged on benches in front of fixed wires from the dynamo, and these would be so fitted with coupling plugs, that the connecting of several hundred batteries would be the work of a very short time. The cost of the renewal of the electric lamps would probably be about the same as the cost of filling, cleaning, and keeping in repair Davy lamps, and that I believe is about 2d. per lamp per week. The supply of oil for ordinary safety lamps costs another 2d. per week, and I think that sum would fully cover the cost of charging the batteries for the electric light. Here, then, is a miner's lamp to which the appellation of safety may be given without any reservation. Whatever its faults, and I am not so partial a judge as to be incapable of seeing them, this electric lamp possesses at least the capital merit of being absolutely safe; free, I believe, from even the suspicion of a possibility of causing an explosion of firedamp. If it is neither so light nor so cheap as the ordinary lamp, it is in both respects at least practicable, and especially is it to be noted that the working cost will probably not be more than that of the ordinary lamps. As regards weight, I am not without hope of being able to reduce it.

Besides its safety, there is one other advantage of occasional importance which this lamp possesses over oil lamps. Oil lamps require air more or less pure to support the combustion of the oil. This lamp requires no air; and there are, unfortunately, times after an explosion of firedamp, when the air of a pit is so foul that no oil lamp will burn in it. With a Fleuss apparatus for breathing, and the electric safety lamp for lighting, the work of exploration, which could hardly be otherwise accomplished, might be carried on, and this, it is reasonable to hope, would be attended with the saving of life.

CHEAP TELEGRAMS.

In anticipation of heavy work yesterday, owing to the coming into operation of sixpenny telegrams, special preparations had been made by the Postal Telegraph Department. An exceptionally large staff had been arranged for, and the two floors comprising the instrument rooms at St. Martin's-le-Grand were peopled by some 1,500 operators—male and female. The first sixpenny telegram came through at 12:4 yesterday morning, containing a congratulatory message, and telegrams of a similar nature were received by the Postmaster-General, the ex-Postmaster-General, Mr. Lamb (secretary of telegraphs), Mr. Fischer (comptroller), and a number of other gentlemen. Among the first telegrams despatched were a number of a highly-amusing character, some evidently the result of much thought on the part of the senders. Among the most amusing were "*Toujours à toi*, you can't expect more for sixpence," and "Awake this October morn, for tanner telegrams are born;" while one sender anxiously inquires, "Can you lend me sixpence?" and another, wiring to a telegraph clerk, hopes "the public won't come it too strong." One riddle, the answer to which has not yet been received, has also passed over the wire—"Why's a sixpenny telegram like a new-born child?" A large number of telegrams arrived in the course of the morning, each claiming to be the first sixpenny telegram from that place, while several consisted of "slangisms" hardly intelligible to the uninitiated. A notable feature of the occasion is the introduction of a new "phraseogram," which is not looked upon with great favour by the authorities. The most simple and expressive is "tannergram," and will doubtless come into equal popularity with "cablegram," which has for many years held its own.

By midday it was evident that the lowering of the tariff had attracted a large number of new patrons to the telegraphic wires. The increase in messages over the number ordinarily received was considerable. There can be no question that but for the extensive preparations made the staff would have been insufficient for the work to be done. The number of operators, however, was ample, and the large amount of work coming in was dealt with more rapidly perhaps than usual. The numerous new hands who have been recently taken on from the Telegraph School well maintained their reputation, and throughout the vast floors devoted to telegraphic instruments there was not a single person idle. Between the hour of twelve and one the increase was most heavily felt in the metropolitan district, where an increase of no less than 53 per cent. over the number of messages sent the day previous was experienced. An interesting feature was the proportion of messages which did not exceed the sixpenny rate, this being out of 1,000 messages 33 per cent. One point noticeable was the number of telegrams with insufficient addresses, a lesson to the public not to cut this important item too short. One message, having no fewer than twelve addresses, had five undeliverable ones, while numerous missives addressed to "Miss Jones, London," or "Mr. Smith, Birmingham," had to be laid aside. One energetic firm in the Midlands issued a telegram with numerous addresses, consisting of a request to "do something to support sixpenny telegrams and the sender." Throughout the morning the operating rooms were visited by a number of gentlemen experienced in telegraphy, among others Mr. F. E. Baines, C.B., Inspector-General of Mails, who viewed with evident interest the establishment of the proposal he made before Parliament some years ago to grant a sixpenny rate for telegrams. It may be mentioned that a large number of code addresses have been registered, three hundred applications having been received yesterday alone.—*The Globe.*

BRITISH ASSOCIATION MEETING, 1885.

ADDRESS TO THE CHEMICAL SECTION, BY PROF. HENRY E. ARMSTRONG, PH.D., F.R.S., SEC. C.S., PRESIDENT OF THE SECTION.

In the Chemical Section of the British Association for the Advancement of Science the advancement of chemistry throughout the British Empire must be a subject of commanding interest. Signs of such advancement are not wanting—the rapid establishment of science colleges in one after another of our large towns; the establishment of the Society of Chemical Industry, which now, only in the fifth year of its existence, numbers over 2,000 members; the granting of a Royal charter to the Institute of Chemistry; the changes introduced at the London University in the regulations for the D.Sc. degree; the report of the Royal Commission on Technical Education, in which the value to chemical manufacturers of advanced chemical knowledge is so fully recognised; the important conference on education held at the Health Exhibition last year; the recent agitation to found a teaching university in London with adequate provision for research—surely all these are signs that the value of higher education must and will, ere long, be generally recognised.

The neglect of chemical research in our British schools has often been forcibly commented upon—of late, especially, by an eminent past-president of this section, Dr. Perkin, whose opinion is of peculiar value, as he is not only world renowned as a chemist, but also as a manufacturer; indeed, as the founder of two distinct important chemical industries. There can be no doubt of the fact and of the dire consequences to our country of such neglect. How is it, then, that such pronounced complaints have been so coldly received; that hitherto they have produced comparatively so little effect, and such slight encouragement is being given to those who, notwithstanding the many difficulties in their way, have steadfastly devoted themselves to research work? I question whether the value of such work has yet been brought home to teachers generally, let alone the public. The *cui bono?* cry is almost invariably met by pointing to some discovery of great pecuniary value as the outcome of research. This argument educationalists very properly refuse to recognise. Too little has been said as to the cause of the neglect so bitterly and properly complained of. Hence it is that I propose again to take up what many may regard as a somewhat threadbare theme.

Everyone will agree with Prof. Sir Henry Roscoe, who in his address last year to this section said "that those who are to become either scientific or industrial chemists should receive as sound and extensive a foundation in the theory and practice of chemical science as their time and abilities will allow, rather than they should be *forced prematurely*"—the italics are mine—"into the preparation of a new series of homologous compounds, or the investigation of some special reaction, or of some possible new colouring matter, though such work might doubtless lead to publication." We must also all cordially agree with him that the aim should be, as he tells us his has been, "to prepare a young man by a careful and fairly complete general training to fill with intelligence and

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success a post either as teacher or industrial chemist, rather than to turn out mere specialists, who, placed under other conditions than those to which they have been accustomed, are unable to get out of the narrow groove in which they have been trained." If it were necessary to show that Sir Henry Roscoe is a believer in research in its proper place, ample proof would be afforded by his statement, "that, far from underrating the educational advantages of working at original subjects, he considers this sort of training of the highest and best kind, but only useful when founded upon a sound and general basis."

But I venture to think that something has to be added in order to completely define the position of those who deplore the slight amount of original work which is being done in British laboratories. We maintain that no one can really "*fill with intelligence and success* a post either as teacher or industrial chemist" who has not been trained in the methods of research; and that, owing to the neglect of research, the majority of students are of necessity trained in a narrow groove. The true teacher and the industrial chemist are daily called upon to exercise precisely those faculties which are developed in the course of original investigation, and which it is barely possible—many would say, perhaps with justice, it is impossible—to sufficiently cultivate in any other manner. In a works the *chemist* is scarcely required as long as all goes well. The quality of the materials used or produced can be controlled by purely routine processes of analysis by the works analyst, or by well trained laboratory boys. But things never do go well for any long period of time. Difficulties are always arising; obscure points have to be investigated; and, if the manufacturer understand his business, improvements have to be effected, which cannot be done unless the conditions under which he is working be understood, as well as the character of the changes which are taking place. Investigation is therefore necessary at every step. No amount of instruction, such as is ordinarily given, in the mere theory and practice of chemical science will confer the habits of mind, the acuteness of vision and resourcefulness required of an efficient chemist in a works, any more than the mere placing of the best tools in a workman's hands will make him a skilful operator.

Such being our position, we maintain that it is essential to make research an integral portion of the student's course in every college which pretends to *educate chemists*. It will not suffice occasionally to set a promising student to investigate, but a number of students, as well as the staff, must always be engaged in original work; in fact, *an atmosphere of research must pervade the college*. It cannot be too clearly recognised that it is this which characterises and distinguishes the German schools at the present time. The student does not learn so much from the one special piece of work with which he is occupied, but a number of his fellow students being also similarly engaged, the spirit of inquiry is rife throughout the laboratory; original literature is freely consulted, and they thus become acquainted with the methods of the old masters; vigorous discussions take place, not only in the laboratory, but also at the most useful institution, the "Kneipe;" the appearance of each new number of the scientific periodicals is keenly welcomed—in fact, a proper spirit of inquisitiveness is awakened and maintained, until it gradually becomes a habit. Probably there is less actual routine teaching done by the staff in the German schools than in our own. I am proud to own my indebtedness to one of them, and I can without hesitation say that I never truly realised what constituted the *science* of chemistry until I came under its influence.

But to realise the state which I have pictured—*to create an atmosphere of research in our science colleges in order that it may be possible for our students to obtain complete training in chemistry*, several things are required. In the first place, it will be necessary that the students come to them better prepared than they are at present; as a rule they are so ill prepared that it is very difficult, if not impossible, in the time at disposal to give such preliminary instruction as is indispensable before higher work can be attempted. Their mathematical knowledge is so ill-digested that it is more often than not necessary to begin by teaching simple proportion, and they look aghast at a logarithm table. They cannot draw—so far have we advanced in our civilisation that the subject is more often than not an "extra" in our schools. They understand a little French; but German, which may almost be called the language of modern science, is indeed an unknown tongue to them. I do not complain of their want of knowledge of science subjects, but of the unscientific manner in which they have been trained at school, and especially of the manner in which their intellectual faculties have become deadened from want of exercise, instead of developed and sharpened. Too many have never acquired the habit of working steadily and seriously; they have not learnt to appreciate the holiness of work*, so that they render the office of teacher akin to that of slave driver instead of to that of friend. What is perhaps worse is their marked inability, often amounting to downright refusal, either to take proper notice of what happens in an experiment or to draw any logical conclusion from an observation. Man is said to be a reasoning being, but my experience as an examiner and teacher would lead me to believe that this fact is altogether lost sight of by the average schoolmaster, who appears to confine himself almost exclusively to the teaching of hard dry facts, and makes no attempt to cultivate those very faculties which are supposed to characterise the human race; or he is so ill-prepared for his work that he fails to understand his duty. These are harsh words, but the evil is of such magnitude that it cannot be too plainly stated; those who, like myself, are brought full face to it fail in their duty if, when opportunity occurs, they do not take occasion to call attention to its existence.

Probably the only remedy—certainly the most effectual, and that which can be most easily applied—is the introduction of a *rational system* of practical science teaching into all our schools, whatever their grade; one effect would be that all the school subjects would of necessity soon be taught in a more scientific manner. I am not one of those who would eschew the teaching of classics, and I do not wish to see science teaching introduced into schools generally, in order that the students who come to me may already have gained some knowledge of science. Under existing circumstances I prefer that they shall not; but I desire its introduction because the faculty of observing and of reasoning from observation, and also from experiment, is most readily developed by the study of experimental science; this faculty, which is of such enormous practical value throughout life, being, I believe—as I have said elsewhere—left uncultivated after the most careful mathematical and literary training. No one has stated this more clearly than Charles Kingsley. We are told that, speaking to the boys at Wellington College, he said:—"The first thing for a boy to learn, after obedience and morality, is a habit of observation—a habit of using his eyes. It matters little what you use them on, provided you do use them. They say knowledge is power, and so it is—but only the knowledge which you get by observation. Many a man is very learned in books, and has read for years and years, and yet he is useless. He knows *about* all sorts of things, but he can't *do* them." This is precisely our complaint—the average schoolboy may know a good deal *about* things, but he can't *do* them. The ordinary school system of training does not, in fact, develop the "wits," to use a popular and expressive term for the observing and reasoning faculties; but it is certain that the wits require training. It is because the teaching of experimental science tends to develop the wits that those among us who know its power are so anxious for its introduction. This cannot be too clearly stated, the popular view—to judge from newspaper discussions—being apparently that science is to be classed with "extras;" that it is good for those who can afford it, but can be dispensed with by those who cannot. This undoubtedly is true of the "science" which is taught the specialist, and I fear even of much of the "science" which is at present taught in schools; let us hope that ere long other views will prevail when the object which it is sought to gain by teaching science is made clear.

While blaming the schoolmaster for his neglect, it must not be forgotten that the teaching of sciences in schools meets with comparatively little encouragement at the hands of our examining bodies and the universities. Again, examinations are too often entrusted to those who have no educational experience, and with most unfortunate results; in no case, probably, is inexperience so inexcusable as in an examiner. Too often, also, the examinations are in the hands of pure specialists, who take too formal a view of their duty, and expect from boys and girls at school as much as from their own students, who are older and devote more time to the work. Such examiners are prone to discourage science by marking too severely; and as their questions govern the teaching, instruction is given in schools without due reference to educational requirements, and in a purely technical style; this, I fear, is the effect of some of the universities' local examinations.

I have it on good authority, that the recent changes in the scheme of the examinations for admission at Sandhurst have forced one large school, well known for the attention paid in it to the teaching of science, to cease to give instruction in science to those of its pupils who propose to compete at these examinations, at once on their deciding to do so. Then, not only are the science scholarships at the universities few in proportion, but the great majority of students pass through their university career without being called upon to gain the slightest knowledge of physical science; yet, more often than not, the teachers are chosen from these. A large proportion become clergymen, and considering the demands upon them and the unbounded opportunities which they have of imparting useful information, there cannot be a doubt that to no other class of the community is a knowledge of natural science likely to be of more value.* Let us hope that the time is near when our universities will no longer be open to this reproach.† Whatever steps they may elect to take, it is before all things important that it be not forgotten that their main purpose must be to influence the schools, so that experimental science may be used as an educational weapon at the most appropriate time, and not when the faculties to be fashioned by it have become atrophied through neglect, as I fear is too often the case, ere the university is reached.

We must carefully guard against being satisfied with the mere introduction of one or more science subjects into the school curriculum; some of those who strenuously advocate the introduction of science teaching perhaps do not sufficiently bear this in mind. Chemistry, physics, &c., may be—and I fear are, more often than not—taught in such a way that it were better had no attempt whatever been made to teach them. I hold that it is of no use merely to set lads to prepare oxygen, &c., or to make experiments which please them in proportion as they more

* In my experience, the behaviour of ordinary day male students is, in this respect, particularly striking in comparison with that of female and evening students. The evening students come with a desire to learn, and the female students are invariably most attentive, and make the fullest use of the opportunities afforded them.

* "I sometimes dream," said Kingsley, "of a day when it will be considered necessary that every candidate for ordination should be required to have passed creditably in at least one branch of physical science, if it be only to teach him the method of sound scientific thought."

† I learnt with the most lively satisfaction, but a few days ago, that Dr. Percival, the late head-master of Clifton College, speaking at a meeting of Convocation at Oxford last term, said:—"If twenty years ago this university had said, from this time forward the elements of natural science shall take their place in responsions side by side with the elements of mathematics, and shall be equally obligatory, you would long ago have effected a revolution in school education." This remark elicited some warm expressions of approval. Dr. Percival, I am sure, has the cordial approval of all science teachers, and he will earn their gratitude, and deserve that of the public at large if he can succeed in inducing his university to take action in accordance with his enlightened views.

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nearly resemble fireworks; and it is not the duty of the schoolmaster to train his boys as though they were to become chemists, any more than it is his duty to fit them to enter any other particular profession or trade; the whole of the science teaching in a school should be subservient to the one object of developing certain faculties. Unfortunately, two great difficulties stand in the way at present—viz., the want of suitable books and of a rational system of teaching science from the point of view here advocated; and the requirements of the universities and other examining bodies. Both books and examinations are of too special a character; they may suit the specialist, but do not meet educational requirements. I have already somewhat fully expressed my views on this subject in a paper read at the Educational Conference in London last year. Although much more might be said, I will only now call attention to the important service which we may render in removing these difficulties.

The reform most urgently needed, in which, as members of the community, not merely as chemists, we are all most interested, is the introduction of some system which will ensure a proper training for teachers. Engineers, lawyers, medical men, pharmacists, have severally associated themselves to found institutions which require those who desire to join the profession to obtain a certain qualification; even chemists are seeking to do this through the Institute of Chemistry. But schoolmasters, although members of what is probably the most responsible, onerous, useful, and honourable of any of the professions, have as yet neither made, nor shown any inclination to make, a united effort to ensure that all those who join their profession shall be properly qualified. Surely the time has come when the subject must receive full public attention; the country cannot much longer remain content that the education of all but those of its sons and daughters who come within the province of the School Board should be carried on without any guarantee that it is being properly conducted.

Glaring as are the faults in the existing school system, and although it rests with the universities and other teaching and examining bodies—if the public do not intervene—to prescribe a proper course of instruction for potential schoolmasters, and to enforce a rational system of training all the mental faculties, we science teachers may meanwhile do much by introducing more perfect methods into our own system of teaching. The students attending our courses belong to various classes; some will become chemists, and require the highest and most complete training; others will be teachers in colleges or schools; many will occupy themselves as consulting chemists or analysts; many others will have to take charge of manufacturing operations in which a knowledge of chemistry is of more or less direct importance and value; not a few will become medical men; and a large proportion, let us hope, will be those who have no direct use for chemistry, although the knowledge will be of great service to them in many ways. Among such we may include architects and builders, engineers, farmers, and even country gentlemen. Have we sufficiently considered the several requirements of all these various classes? I submit, with all due deference, that we have not! Our attention has been too exclusively directed to the training up of the future analyst; the instruction has been of too technical a character.

I know it is rank heresy to say so, but I maintain that in future far less time must be devoted to the teaching of ordinary qualitative and quantitative analysis, and that *technical instruction* as now given in these subjects must find its place later in the course. Our main object in the first instance must be to fully develop the intellectual faculties of our students—to encourage their aspirations by inculcating broad and liberal views of our science, not an infinite number of petty details. We must not merely teach them the principles and main facts of our science, but we must show them how the knowledge of those facts and principles has been gained; and they must be so drilled as to have complete command of their knowledge. The great majority will not be required to perform *ordinary* analyses, either qualitative or quantitative; it will be sufficient for them to have gained such an amount of practical experience that they thoroughly understand the principles of analysis; that they shall have learnt to appreciate the sacredness of accuracy; and that they shall have acquired sufficient manipulative skill to be able when occasion requires to carry into execution the analytical process which their text-books tell them is applicable, and even, if necessary, to modify the process to suit circumstances.

Chemistry is no longer a purely descriptive science. The study of carbon compounds and Mendeljeff's generalisation have produced a complete revolution. The faults in our present system are precisely those which have characterised the teaching of geography and history, and which are now becoming so generally recognised and condemned; in fact, no better statement of the manner in which I conceive chemistry should be taught could be given than by broadly applying to the teaching of chemistry what was said by Professor Seeley, at the International Conference on Education last year, in an important paper on the teaching of history.

The necessity for some change must, I venture to think, be patent to all thoughtful teachers, and especially to those who are called upon to fulfil the painful duties of an examiner. The railway book-stalls have made us acquainted with "Confessions" of all sorts, but if the "Confessions of an Examiner" were to be written they would be far more heart-rending than any. The examiner in chemistry, let him go where he will, scarcely dare ask a question to which the answer cannot be directly read out from a text-book. He will be told "that such and such a compound is formed by the action of so and so upon so and so," but he will usually find blank ignorance of the phrase "by the action of," and as to the mode of performing the operation. The examiner would, however, be bound to agree with the teacher that it is almost impossible to induce students to seek information outside the lecture room, and except in the ordinary cram text-books, and that it is hopeless to expect them to devote attention to anything unless it will pay in a subsequent examination; in fact, that the old university spirit of acquiring knowledge for its own sake is almost unknown among our science students. Herein lies one of the teacher's most serious difficulties, as he is more often than not bound to teach in a particular way, or to teach certain subjects, in entire opposition to his own views, in order to qualify his students to pass a particular examination. For example, many of our colleges now distinctly state that their courses are intended to qualify students to pass the examinations of the London University, and hence they are governed by the requirements of that university, which vary more or less as the examiners are periodically changed. The examiner, on the other hand, is often placed in a difficult position. It is clear to him that the system under which the students he is called upon to examine have been taught is a bad one; yet he feels that he has no right to set questions such as he honestly believes should direct the teaching into proper channels, because he knows that the teacher is immovable, and it is not fair to make the examinees the victims of a system for which they are not responsible. Hence, perforce, the teacher goes on teaching badly and the examiner examining badly. Difficulties of this kind are bound to make themselves felt at a transition period like the present, and will only disappear if we recognise the grave responsibility which rests upon ourselves and improve our methods of teaching and our text books. These, in too many instances, are unsuited to modern requirements, and are being made worse by stereotyping, and the practice which is gradually creeping in of merely changing the date on the title-page and the numeral before the word "edition," thus engendering the belief that the information is given up to date.

Both in teaching and examining two important changes ought forthwith to be made—our students ought at the very beginning of their career to become familiar with the use of the balance; and the imaginary distinction between so-called inorganic and organic compounds should be altogether abandoned. I do not mean that students should be taught quantitative analysis as ordinarily understood, but that instead of endeavouring to make clear to them by explanation only the meaning of terms such as equivalent, for example, we should set them to perform a few simple quantitative exercises in determining equivalents, &c. It can easily be done, and terms which otherwise long remain mythical acquire a real meaning in the student's mind. That the elements of the chemistry of carbon compounds do not find a place at a very early period in the course of instruction is one of those riddles connected with our system which it is impossible to answer. Attention was once pithily directed to the fact in my hearing by a scientific friend—not a chemist—who said he had often felt astonished that, although he had learnt a good deal of chemistry, the chemistry of the breakfast-table was practically a sealed book to him, common salt being the one object of which he felt he knew something.

I may here urge that there is one great error which we *must* avoid in the future, that of overworking our students, in the sense of obliging them to pay attention to too many subjects at a time. This is done more or less, I believe, in all our science schools, and medical students are peculiarly unfortunate in this respect. It is to some extent necessitated by the deficient preliminary education of our students; but I believe that I am justified in stating that it is also partly, perhaps mainly, due to the fact that the curriculum is too often imposed by lecturers who are directly interested in the attendance of students at their lectures. This is one of the great difficulties in the way of higher education, and the continuance of the evil is probably in a measure due to inappreciation of what constitutes higher education and culture; neither consist in a smattering of knowledge of a variety of subjects such as is too often required at present.

The more general appreciation of the value of science undoubtedly depends to a considerable extent on improvements such as I have indicated being introduced. When such is the case, we may hope that a large number of students will enter our chemical schools, not with the intention of becoming chemists, but because it will be recognised that the training there given is of high educational value, and that a knowledge of chemistry is of distinct service in very many avocations.

We may also hope that it will be possible ere long to teach chemistry properly to medical students. Seeing that the practice of medical men largely consists in pouring chemicals into that delicately organised vessel the human body, and that the chemical changes which thereupon take place, or which normally and abnormally occur in it, are certainly not more simple than those which take place in ordinary inert vessels in our laboratories, the necessity for the medical man to have a knowledge of chemistry—and that no slight one—would appear to ordinary minds to stand to reason; that such is not generally acknowledged to be the case can only be accounted for by the fact that they never yet have been taught *chemistry*, and that the apology for chemistry which has been forced upon them has been found to be of next to no value. No proof is required that the student has ever performed a single quantitative exercise; and I have no hesistation in saying that the examinations in so-called practical chemistry, even at the London University, are beneath contempt. After more than a dozen years' experience as a teacher under the system, I can affirm that the knowledge gained is of no permanent value, and the educational discipline *nil*. Here the reform must be effected by the examining boards. It is for them to insist upon a satisfactory preliminary training, and they must so order their demands as to enforce a proper system of practical teaching; and if chemistry is to be of real service to medical men more time must be devoted to its study. Physiological chemistry is taught nowhere in our country, either at the universities or at any of our great medical schools; let us hope that the publication of works like those of Gamgee and Lauder Brunton may have some effect in calling attention to this grievous neglect of so important a subject.

Having dealt with the educational aspect of the question, let me now briefly refer to some other difficulties which seriously hinder research. It has been more or less openly stated that the teachers in our chemical schools might themselves do far more. Is this the case? I do not think so. I believe it is not the staff, in most cases, who are primarily in fault.

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Under our peculiar system of placing the government of science schools in the hands of those who have little, if any, experience as educationalists and a little knowledge of or sympathy with science, the appointments are sometimes made without the slightest reference to capability of inciting and conducting original investigation, and without any proof having been given even of a desire to promote higher education in the only possible way—by research; nevertheless, experience shows that, as a rule, fair use is made by teachers of their opportunities. The opportunities afforded us are indeed few. In the first place, the amount of actual routine teaching we are called upon to perform is very considerable, many of us having to conduct evening as well as day classes; and the work is often of the most harassing description, owing to the want of interest displayed by the students. The assistance provided is also too often inadequate, and much which should be done by assistants is therefore thrown upon the principals. Higher work under these conditions is practically out of the question, not so much because it is impossible to snatch at intervals a few hours per week, but because the attention is so much taken up in the preparation of lectures and laboratory and tutorial teaching that it is impossible to secure that freedom of mind and concentrated attention which are essential to the successful prosecution of research. Bad, however, as is often the position of the principals, that of the junior staff is usually far worse. During official hours they are entirely occupied in tutorial work, and what little energy remains must more often than not be devoted to coaching or literary work, to supplement the too modest income which the salary attached to their official position affords. Under these circumstances, it is remarkable that so much enthusiasm should prevail among them on the subject of research. The tradition which prevails in the German schools, that the junior staff are bound to find some time for original work, is almost unknown in this country, and too often difficulties are raised, rather than facilities afforded, when the desire is manifested; we do not, in fact, sufficiently honour the assistant as the potential professor. It has also often struck me as remarkable, and it must have struck others who understand the German system, that in this practical country we have not adopted that cheap luxury—the Privat-Docent, who costs nothing and exercises a most important function in promoting higher education. The explanation of this and many other anomalies lies in the fact that very few among us realise what a university is; a clear exposition of the Scotch and German systems would be of great value in these days of new universities and university colleges.

I believe that in most, if not all, of the German chemical schools a private research assistant is placed at the disposal of the professor. Will this ever be the case here? The want of material assistance is not only felt in this respect, however; few of our chemical schools are really efficiently equipped; most of them are seriously in want of larger and more expensive apparatus, of suitable specimens, &c.; the annual grant barely suffices for the purchase of the ordinary chemicals and the payment of unavoidable current exposnes, so that, as a rule, nothing remains to meet the expenses of research work, *i.e*, of higher education. In point of fact, nearly all of those who are engaged in research are doing so at their own expense; important assistance, for which we cannot be too thankful, is indeed received from the various research funds, but the proportion which the grants bear to the total sum expended is not large. I am sure we all recognise that each one of us is bound, according to his abilities and the opportunities he has, to add to the stock of knowledge, and that the keenest intellectual pleasure is derived therefrom; but it must not be forgotten that the results we obtain are very rarely of immediate practical value, and that as a rule *we* reap no pecuniary advantage. I venture to think, in fact, that it is remarkable that so much, not that so little, is done, and that reproach rests very lightly upon the profession in this matter. Whether our national pride will prevent our being much longer beholden to foreigners for by far the greater number of new facts in chemistry is a difficult question to answer, and must rest with the public.

The occasions on which we teachers of science subjects are able to bear witness in public are of necessity few. Deeply sensible, not only of the honour, but also of the responsibility of my position as President of this Section, I felt that it was my duty to avail myself of this opportunity. Being a teacher who is interested in teaching; being convinced of the existence of most serious faults in our educational system; feeling that the present is a most critical period, I have not hesitated to speak very freely. Some of the difficulties to which I have referred might soon disappear if science teachers generally would agree to consider them together, and I believe that it would be a very great advantage if an association for the discussion of educational questions were formed of the staffs of our science colleges throughout the country. The special difficulties which surround our science colleges, and prevent them from exercising their full share of influence upon the advancement of our national prosperity might also be removed at no distant date; but I see only one way of accomplishing this, and I fear it will hardly find favour—it is by their all becoming vested in the State. In this country we like to do things in our own way, and the objection will at once be raised that this would deprive all the colleges of their individuality, and would tend to crush originality and to stereotype teaching. If I thought so, I should never make the suggestion. But it would not, provided that complete academic freedom were secured to the staff, and each college were left to adjust itself to local requirements; efficiency would be maintained by the competition of the various colleges. Local enterprise, which has hitherto been trusted to, is clearly breaking down under the tremendous strain of modern educational requirements; some change must ere long be made.

I now pass to the consideration of a subject of special interest in this section, which I think requires the immediate earnest attention of chemists and physicists combined—that of *Chemical Action*. In his Presidential Address to the Association last year, Professor Lord Rayleigh made only a brief reference to chemistry, but many of us must have felt that his few remarks were pregnant with meaning, especially his reference to the importance of the principle of the dissipation of energy in relation to chemical change. A year's reflection has led me to think them of peculiar weightiness and full of prophecy. I would especially draw attention to the closing paragraph of this portion of his address:—"From the further study of electrolysis we may expect to gain improved views as to the nature of the chemical reactions, and of the forces concerned in bringing them about. I am not qualified—I wish I were—to speak to you on recent progress in general chemistry. Perhaps my feelings towards a first love may blind me, but I cannot help thinking that the next great advance, of which we have already some foreshadowing, will come on this side. And if I might, without presumption, venture a word of recommendation, it would be in favour of a more minute study of the simpler chemical phenomena."

Chemical action may be defined as being any action of which the consequence is an alteration in molecular constitution or composition; the action may concern molecules which are of only one kind—cases of mere decomposition, of isomeric change and of polymerisation; or it may take place between dissimilar molecules—cases of combination and of interchange. Hitherto it appears to have been commonly assumed and almost universally taught *by chemists* that action takes place directly between A and B, producing AB, or between AB and CD, producing AC and BD, for example. This, at all events, is the impression which the ordinary average student gains. Our text-books do not, in fact, as a rule, deign to notice observations of such fundamental importance as those of De La Rive on the behaviour of nearly pure zinc with dilute sulphuric acid, or the later ones of Faraday ("Experimental Researches," Series VII., 1834, 863 *et seq.*) on the insolubility of amalgamated zinc in this acid. Belief in the equation $Zn + H_2SO_4 = H_2 + ZnSO_4$ hence becomes a part of the chemist's creed, and it is generally interpreted to mean that zinc *will* dissolve in sulphuric acid, forming zinc sulphate, not, as should be the case, that *when* zinc dissolves in sulphuric acid it produces zinc sulphate, &c. In studying the chemistry of carbon compounds, we become acquainted with a large number of instances in which a more or less minute quantity of a substance is capable of inducing change in the body or bodies with which it is associated without apparently itself being altered. The polymerisation of a number of cyanogen compounds and of aldehydes, the "condensation" of ketonic compounds and the hydrolysis of carbohydrates are cases in point; but so little has been done to ascertain the nature of the influence of the contact-substance, or *catalyst*, as I would term it, the main object in view being the study of the product of the reaction, that the importance of the catalyst is not duly appreciated. Recent discoveries, however—more particularly Mr. H. B. Dixon's invaluable investigation on conditions of chemical change in gases, and the experiments of Mr. Cowper with chlorine and various metals, and of Mr. Baker on the combustion of carbon and phosphorus—must have given a rude shock, from which it can never recover, to the belief in the assumed simplicity of chemical change. The inference which I think may fairly be drawn from Mr. Baker's observations—that *pure* carbon and phosphorus are incombustible in *pure* oxygen—is indeed startling, and his experiments must do much to favour that "more minute study of the simpler chemical phenomena" so pertinently advocated by Lord Rayleigh.

But if it be a logical conclusion from the cases now known to us, that chemical action is not posssible between any two substances other than elementary atoms, and that the presence of a third is necessary, what is the function of the third body—the catalyst, and what must be its character with reference to one or both of the two primary agents? In the discussion which took place at the Chemical Society after the reading of Mr. Baker's paper, I ventured to define chemical action as *reversed electrolysis*, stating that in any case in which chemical action was to take place it was essential that the system operated upon should contain a material of the nature of an electrolyte ("Chemical Society *Proceedings*," 1885, p. 40). In short, I believe that the conditions which obtain in any voltaic element are those which must be fulfilled in every case of chemical action. There is nothing new in this; in fact, it practically was stated by Faraday in 1834 ("Experimental Researches in Electricity," Series VII." §§ 858, 859*); and had due heed been given to Faraday's teachings we should scarcely now be so ignorant as we are of the conditions of chemical change.

The questions—What is Electrolysis? What is an Electrolyte? are all important to the chemist, if my contention be accepted. Moreover, the

* "Those bodies which, being interposed between the metals of the voltaic pile, render it active, *are all of them electrolytes*, and it cannot but press upon the attention of everyone engaged in considering this subject, that in those bodies (so essential to the pile) decomposition and the transmission of a current are so intimately connected that one cannot happen without the other. If, then, a voltaic trough have its extremities connected by a body capable of being decomposed, as water, we shall have a continuous current through the apparatus; and whilst it remains in this state we may look at the part where the acid is acting upon the plates and that where the current is acting upon the water as the reciprocals of each other. In both parts we have the two conditions, *inseparable in such bodies as these*, namely, the passing of a current and decomposition; *and this is as true of the cells in the battery as of the water-cell*; for no voltaic battery has yet been constructed in which the chemical action is only that of combination; *decomposition is always included*, and is, I believe, an essential chemical part.

"But the difference in the two parts of the connected battery—that is, the decomposition or acting cells—is simply this; in the former we urge the current through, but it, apparently of necessity, is accompanied by decomposition; in the latter we cause decompositions by ordinary chemical actions *(which are, however, themselves electrical)*, and, as a consequence, have the electrical current; and as the decomposition dependent upon the current is definite in the former case, so is the current associated with the decomposition also definite in the latter."

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consideration of chemical action from this point of view almost of necessity obliges us also to consider what it is that constitutes chemical affinity. I will not presume to offer any opinion on this subject; but I would recall attention to the prominence which so great an authority as Helmholtz gave in the last Faraday Lecture ("Chemical Society *Transactions*," 1881, 277) to the view held by Faraday, and which is so definitely stated in a passage in his "Experimental Researches"* (Series VII. 918, also 850 and 869).

Helmholtz used the words: "I think the facts leave no doubt that the very mightiest among the chemical forces are of electric origin. The atoms cling to their electric charges, and opposite electric charges cling to each other; but I do not suppose that other molecular forces are excluded, working directly from atom to atom." In the passages which immediately follow, this physicist then makes several statements of extreme importance, which directly bear upon the subject I desire to discuss, and which, therefore, I quote.†

The interpretation of Faraday's law of electrolysis which Helmholtz has brought under the notice of chemists is of the most definite and far-reaching character. Does it, however, at all events in the form in which he has put it forward, accord sufficiently with the facts as these present themselves to the chemist's mind? All will recognise that the chemical changes effected by a current in a series of electrolytic cells are equivalent to those which take place within the voltaic cells wherein the current is generated; but in neither case is the action of a simple character; in both a variety of chemical changes takes place, the precise character of which is but imperfectly understood, and we are unable to assign numerical values, either in terms of heat or electrical units, to most of the *separate* changes. Moreover, many compounds are not electrolytes, while others which are regarded by the chemist as their analogues are very readily decomposed by a current of low E.M.F., although no great difference is to be observed in their "heats of formation;" liquid hydrogen chloride on the one hand, and fused silver chloride on the other, may be cited as examples. Again, how are we to interpret on this theory such changes as that involved in the conversion of stannic into stannous chloride? The former, I suppose, is to be regarded as consisting of an atom of quadrivalent tin charged with four units of, say, positive electricity, and of four atoms of univalent chlorine, each carrying a unit charge of negative electricity; on withdrawal of two of the chlorine atoms, the residual $SnCl_2$ will have two free unit charges of positive electricity. We know that when the temperature is sufficiently lowered two such residues unite, forming Sn_2Cl_4, and it is not improbable that crystalline stannous chloride represents a still later stage of condensation. Is this compatible with the theory? That cases of this kind are contemplated would appear from the reference to "unsaturated compounds with an even number of unconnected units of affinity," which we are told may be charged with equal equivalents of opposite electricity; and also from the allusion to the existence of molecules of elementary substances composed of two atoms. It is more than probable that these anomalies would disappear on fuller statement of his views by the author of the theory; I have ventured to call attention to them in the hope of eliciting such statement.

Helmholtz tells us that electrolytes belong to the class of typical compounds, the constituents of which are united by "atomic affinities," not to the class of "molecular aggregates." Is this the fact? Before chemists can accept this conclusion many difficulties must be removed which appear to surround the question. In the first place, it is in the highest degree remarkable that, with the one single exception of *liquefied* ammonia, *no known binary hydride is in the liquid state an electrolyte*, liquid hydrogen chloride, bromide and iodide, for example, withstanding an E.M.F. of over 8,000 volts (8,040 De la Rue cells; Bleekrode). Water, again, according to Kohlrausch's most recent determinations, has an almost infinite resistance. Yet a mixture of hydrogen chloride and water readily conducts, and is electrolysed; an aqueous solution of sulphuric acid behaves similarly, although the acid itself has a very high resistance.* Very many similar examples might be quoted, but it is well known that aqueous solutions generally conduct more or less perfectly, and are electrolysed.†

(To be continued.)

* "All the facts show us that that power commonly called chemical affinity can be communicated to a distance through the metals and certain forms of carbon; that the electric current is only another form of the forces of chemical affinity; that its power is in proportion to the chemical affinities producing it; that when it is deficient in force it may be helped by calling in chemical aid, the want in the former being made up by an equivalent of the latter; that, in other words, *the forces termed chemical affinity and electricity are one and the same.*"

† "Several of our leading chemists have lately begun to distinguish two classes of compounds—viz., molecular aggregates and typical compounds, the latter being united by atomic affinities, the former not. Electrolytes belong to the latter class. If we conclude from the facts that every unit of affinity is charged with one equivalent, either of positive or of negative electricity, they can form compounds, being electrically neutral, only if every unit charged positively unites under the influence of a mighty electric attraction with another unit charged negatively. You see that this ought to produce compounds in which every unit of affinity of every atom is connected with one, and only one, other unit of another atom. This, as you will see immediately, is the modern chemical theory of quantivalence, comprising all the saturated compounds. The fact that even elementary substances, with few exceptions, have molecules composed of two atoms makes it probable that even in these cases electric neutralisation is produced by the combination of two atoms, each charged with its full electric equivalent, not by neutralisation of every single unit of affinity. Unsaturated compounds with an even number of unconnected units of affinity offer no objection to such an hypothesis; they may be charged with equal equivalents of opposite electricity. Unsaturated compounds with one unconnected unit, existing only at high temperatures, may be explained as dissociated by intense molecular motion of heat, in spite of their electric attractions. But there remains one single instance of a compound which, according to the law of Avogadro, must be considered as unsaturated even at the lowest temperature—namely, nitric oxide (NO), a substance offering several very uncommon peculiarities, the behaviour of which will be perhaps explained by future researches." The popular mistake is here made of assuming that elementary substances, with few exceptions, have molecules composed of two atoms. We now know considerably over seventy elements, but of these the molecular weights in the *gaseous* state of only thirteen have been satisfactorily determined. The gaseous elements hydrogen, oxygen, nitrogen and chlorine, and also bromine, iodine and tellurium, have diatomic molecules; phosphorus and arsenic have tetratomic molecules; those of sulphur are hexatomic, and selenium molecules are probably of similar constitution, but more readily broken down than those of sulphur; lastly, cadmium and mercury molecules are monatomic. It is more than probable that carbon, and also silicon and boron form highly complex molecules. Of the remaining undetermined elements, the greater number are metals, and it is not unreasonable to assume that many of these will be found to resemble cadmium and mercury in molecular composition. It is clear, however, that at present we have no right to say that the elementary molecules are, as a rule, diatomic. It would assist in removing this error if chemists would consistently place *after* the symbol the numeral indicating the "atomicity" of the elementary molecule—thus, Hg_1, Cd_1, O_2; and if in all cases when a numeral is absent, or is placed *before* the symbol, it were understood that advisedly no indication of the molecular state is afforded.

* It is more than probable that the most nearly pure sulphuric acid which can be obtained is not homogeneous, but is at least a mixture of H_2SO_4, $H_2S_2O_7$ and "hydrated compounds" in proportions depending on the temperature, and hence that (pure) sulphuric acid, H_2SO_4, like water, would behave as a dielectric.

† On the other hand, it is remarkable that, whereas liquefied ammonia may be electrolysed, an aqueous solution of ammonia is a most imperfect conductor (Faraday, F. Kohlrausch), although solutions of ammonium salts compare favourably in conductivity with corresponding sodium and potassium salts. This fact serves *somewhat* to allay the suspicion that Bleekrode did not take sufficient precautions to dry the ammonia; but his result cannot, I think, be accepted as final, on account of the relatively high E.M.F. required, and the repetition of the experiment, with every precaution to ensure purity of the gas, is most important. Faraday regarded the decomposition of ammonia on electrolysis of its solution as merely the result of secondary action.

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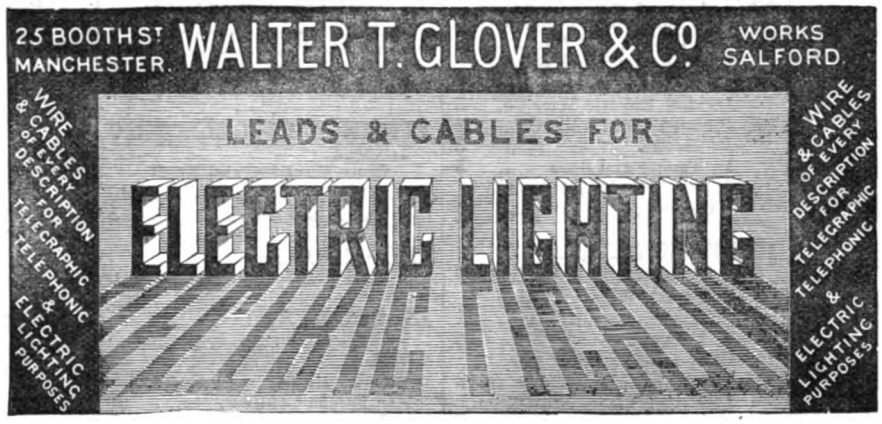
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THE INTERNATIONAL INVENTIONS EXHIBITION.

Dynamo-Electric Machinery.

BY W. M. MORDEY.

The Brush Dynamo.—About eight years ago, when this well-known dynamo was designed, electric lighting may be said to have been in its infancy. At that time public attention had not been seriously drawn to the subject in its practical and commercial aspects. The supply of electricity and what was called the "subdivision of the electric light" had not become burning questions, even to electricians. Men very prominent in physical science—even specially in electrical science—were to be found who knew practically nothing about it. When an arc light was required it was nearly as likely to be supplied by a Grove or Bunsen battery as by a dynamo or magneto machine. And if supplied by the latter it was thought a very fine thing when a fair arc light was kept in operation for a whole evening. Electric arc lamps or "regulators," as they were called, existed in no great variety, and few possessed qualities demanding admiration. The importance of the great principles of the economy of high tension working had not been perceived—the principles themselves had not been formulated. It was a time when scientists convinced themselves and others, by the aid of abstruse calculations, that copper conductors of enormous thickness would be required to electrically transmit a few hundred horse-power from Niagara to New York. The incandescent lamp had not taken practical shape. Edison was still experimenting with platinum and iridium, and Swan was making no outward or visible sign. But chaos was soon to give place to comparative order. Much useful work was being done quietly in laboratory and workshop by many men. Among them, Brush in America, and Jablochkoff in France had developed their arc light systems, which, although entirely differing in general principles as well as in details, each succeeded in producing for the first time, from one machine, a considerable number of arc lights of moderate power. We need not compare these two systems. Their relative values may fairly be estimated on the basis of the success each has achieved. In one respect these earliest arc light systems resembled each other—they were launched on the world in a state of completeness which allowed of immediate application.

In the system which, in its most important part, the dynamo, we have to consider, there was a singular absence of variation or development as years went on. Brush saw clearly that in order to make arc lighting successful and practical a wide distribution of arcs of moderate power from a common centre was necessary, and that this could only be economically effected by the use of high tension and small current. He saw that it was most important that the dynamo should possess such qualities as certainty of action, the power to run continuously, accessibility, and ease of partition, and that highly skilled labour in connection with this and every other part of the plant should not be necessary. Consequently, he gave the dynamo a sound mechanical character, reduced the necessity for attention to a minimum, and designed the commutator—the only wearing part—in such a way that the wearing segments could be immediately replaced when required. This done, he designed machines of different sizes, all on the same lines, capable of supplying various numbers of lamps. An arc lamp which would work under almost any conditions, and which was eminently adapted to meet the conditions of the circuits, was added, and the system was at once a technical success. Brush was satisfied for the time with having the most perfect mechanical generator of electricity, and at having arrived at an economy of application of electricity far beyond anything that had hitherto been effected, by means of the high tension which was for the first time made available; and hence the large number of lamps and vastly improved distribution of light by means of one small lead. "Efficiency of conversion" was at the time quite a secondary object; in fact, the term had not then been coined, and the idea it expresses was perhaps scarcely in existence in connection with electrical machines.

Facility of manufacture was secured by rigidly adhering to stereotyped forms, allowing nothing to interfere with routine production in the workshop, or with the interchangeability of parts in the plant. Thus for a long time a dynamo was produced which maintained its form unaltered, even in detail, for several years; and the first great improvement in the form of a new wrought-iron laminated armature came into existence, not so much perhaps as a new invention as a natural growth, after a period of six years from the first introduction of the complete Brush system.

A specimen of the Brush machine with the improved armature was working in the electric light shed during the whole of the Health Exhibition last year. This year two of the improved machines, and one of the old type are working in the shed; in addition to which the Brush Corporation exhibit at their stall in the East Arcade skeleton armatures of both the old cast-iron and the new laminated wrought-iron forms, partly wound, and in a state which affords the best means of comparison of the two types.

The old form of armature is well known. It consisted of a ring of cast iron, grooved on the sides and periphery, and with spaces, or "pockets," as they are called, having parallel sides for the reception of the coils. Fig. 4 shows a portion of one of these armature cores.

Fig. 2.

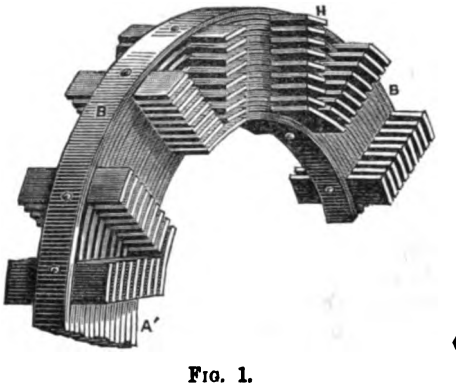

Fig. 1.

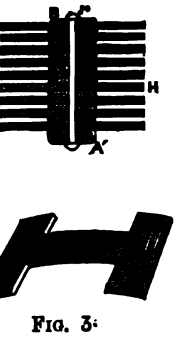

Fig. 3.

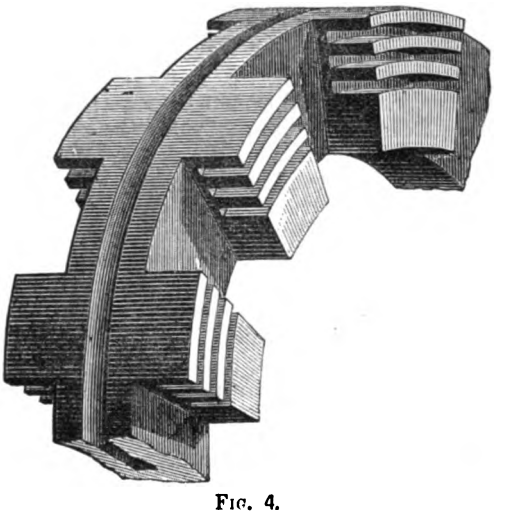

Fig. 4.

The new armature, the construction of which is shown in Figs. 1, 2, and 3, is the same in general outline as the old one, but it is formed by winding up a volute spiral of iron strip or ribbon (B, Figs. 1 and 2) on an inner iron foundation ring of suitable strength (A', Figs. 1 and 2). Between the successive turns or convolutions of the ribbon, and held by them as the process of construction is carried out, are H-shaped pieces of sheet iron (Fig. 3) of the same thickness as the ribbon, the ends of the parallel portions of these H-shaped pieces forming "Pacinotti projections" passing out from the core between the several

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coils, and approaching closely to the pole pieces. These pieces are secured by radial rivets (*r*, Fig. 2) to prevent movement on their part, and to strengthen the armature as a whole. The figures are, for the sake of clearness, purposely rather diagrammatic, and on that account give an incorrect idea of the thickness of the plates, and of the degree of lamination. As a matter of fact, the iron is very thin, and the number of pieces employed is very much greater than shown by the figures, which, however, serve to give a correct idea of the mode of construction.

The improvement effected by the new armature is entirely due to the almost complete elimination of eddy currents. The sizes of the various armatures are the same as before, and the winding is unaltered. In the old armature, although the iron was almost severed by the deep grooves cut or cast in it, there were in some places solid masses of metal of considerable size, and nowhere did the grooving produce anything approaching the fine lamination which is necessary if the eddy currents are to be prevented.

The gain obtained by the use of the laminated armature over the old form amounts, as far as output is concerned, to as nearly as possible 50 per cent. at the normal working speed of the machines. It may, however, be better expressed by taking the case of one of the new as against one of the old armatures, and finding the various gains. Thus the new laminated armature does the normal work of the old one with a 34 per cent. decrease in speed, a decrease in power absorbed of over 20 per cent., and an increase in "commercial efficiency" of 15 per cent.

It will be seen that one result of the alteration is a large increase in the surface of the iron exposed to the air. There is an advantage in this, inasmuch as it allows of an extremely rapid dissipation of heat. So good is the ventilation that it would enable the armature to work and to keep moderately cool with a far greater loss in heat caused by eddy currents than is the case even with the old solid armatures; and it will, therefore, readily be imagined that this increased ventilation obtained by the new construction, where so little facility is offered for the generation of these currents, enables the armature core practically to keep "cold." The increased ventilation is incidental to, but is not a special object of, the improvement; and it could, in fact, very well be dispensed with. "Prevention is better than cure" is an adage that applies forcibly to the subject of heat loss in dynamos; and, at the best, getting rid of heat by good ventilation is an unsatisfactory way out of the difficulty. Ventilation may cause heat to be dissipated, but it cannot increase economy (except very slightly, by its effect on the resistance of the wire); therefore, we see that the gain in economy is not, and cannot be, the result of ventilation. This gain is caused by the "prevention" and not by the "cure" of what was the occasion of the loss.

As the writer has facilities for experiment with these dynamos, he is able to give some of the results of tests which he has made.

In Fig. 5 three curves are given, which show at a glance the output of the machines. The curves were constructed by working the machines at various speeds; the external circuit in each case consisting of open resistance coils of iron wire of such a size that the temperature was not much raised by the current which traversed them.

The temperature of the coils is, of course, not a point of any importance as far as the output of the dynamo is concerned, as smaller wire obtaining a much higher temperature would serve the purpose; but in small wire the variations of resistance due to changes of temperature are so large that more adjustment is required to obtain any required quantity, and experiments cannot therefore so readily be carried out. Measurements of this kind are made with the greatest facility when the value of resistance is least altered by the passage of the current. In these experiments the resistance was arranged at each speed so that the current was 10 amperes, this being the normal working current of the dynamos. The difference of potential at the terminals was then taken by an Ayrton and Perry voltmeter, into the circuit of which resistance could be introduced to render it suitable for measuring the high potential maintained. In the case of the larger machines nearly 3,000 volts were measured in this way with considerable accuracy, as checked by taking the product of current and resistance. In Fig. 5 ordinates are difference of potential at terminals, abscissæ being revolutions. As the current was 10 amperes throughout, ordinates may also be taken to represent watts (E × 10). The lower curve, A, is that of an old type armature; B is the curve of the improved armature of American construction; and C shows the results obtained in the latest form of armature constructed in the works of the Brush Corporation in London, the output in this latter being higher than that given by the American machines, as a result of some modifications introduced on "this side." These curves were all taken with the same field magnets, the armatures only being different. The dynamo was size No. 7, the old "16-lighter," the diameter of the armature being 20 inches.

If taken comparatively instead of actually the curves almost equally well express the results obtained with the other sized machines, the relative heights of the ordinates giving the comparative output in volts or watts for any speed.

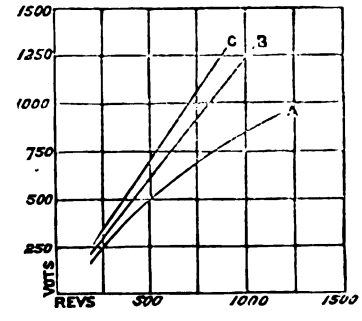

FIG 5.

There is a striking dissimilarity in these curves which demands some explanation. It will be noticed that B and C are straight lines—they are not "curves" at all—while A, the curve of the solid armature, has a decided bend in it, the relative output falling away rather rapidly as speed is increased. There is no such falling off in the lines B and C, and it may be interesting to mention that the writer has run one of these armatures up to a most unsually high speed to ascertain whether any turning down of the curve takes place under such circumstances, with the result that even at speeds altogether above the limits of practice no indication was found of any such tendency. It is not difficult to trace the cause of the fall of the curve C. It is not due to saturation of the field-magnets, because the current being constant at one value the excitation is the same throughout. It is certainly not a result of any extension of the "lead" produced by increase of speed. There is no such thing as an alteration of lead from this cause, and it is noteworthy that the position of the brushes is the same throughout the whole range of speed as long as the current is maintained constant. This matter of the supposed relation of speed to displacement of the brushes was experimentally examined by the present writer some time ago with reference to the Brush dynamo, as well as to machines of another type,* and it may be well to mention that the experiments with the new machine fully bear out the conclusions arrived at as a result of that inquiry. Neither is the fall in the curve the result of any increase in the current collected from the armature, which, of course, is constant. Such an increase, if it took place, would produce this effect; but another explanation must be sought, and we are left with the only remaining one, viz., that it is caused by the demagnetising action of our old foes the eddy currents, which, being generated in masses of iron of low resistance, attain a large value when the E.M.F. to which they are due rises with the speed. It might be thought that in the laminated armature the same thing would occur if only to a small extent, but as experiment does not bear out this expectation it must be assumed that in it, even at the highest speeds, the effect is not sufficiently prejudicial to be perceptible.

* See Prof. Thompson's "Dynamo-Electric Machinery," pp. 396-398.

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It will be evident from what has been stated above that the gain in output costs very little. And this point is one of very considerable importance, not only in this improvement of Brush's, but in all armatures of any allied type. It shows how strong is the reaction between eddy currents and the currents in the conductor proper. In eliminating eddy currents in the iron, not only is the waste of energy due to those currents avoided, and the machine made more economical in consequence; but the E.M.F. in the conductor is increased, and the machine is made capable of doing more work, or of doing the same work at a lower speed than before. These results show that there has been, as it were, a transfer of work from the armature to the external circuit, that the energy which previously was being wastefully expended in producing currents which heated and tended to demagnetise the iron of the armature is now, without any increase of speed, producing results which appear as heat and light in additional lamps on the external wire.

Two of the three Brush dynamos used at the Exhibition are constructed to yield a current of 20 amperes, for the purpose of feeding arc lamps of greater power than those usually employed in the Brush system, which, as is well known, are worked with a current of 10 amperes. This doubling of the current is readily effected by merely altering the connections of the machine, and without any modification in the winding. As ordinarily connected, the coils, which are diametrically opposite one another, are joined in series, each of the two ends of the double coil being connected to a commutator plate. By joining each pair of coils parallel, instead of in series, the E.M.F. is halved and the current is doubled. Similarly, instead of connecting the four field-magnet coils in series, as is done with the 10-ampere dynamos, they are joined in the 20-ampere machines in question in multiple series, two and two, thus retaining their normal excitation. Figs. 6 and 7 show the

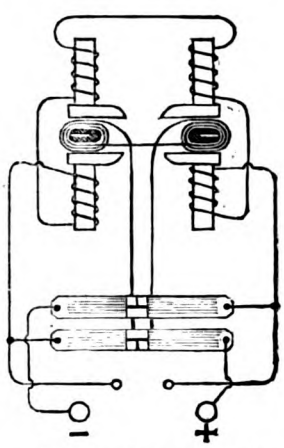

FIG. 6.—Connections for 10 amperes.

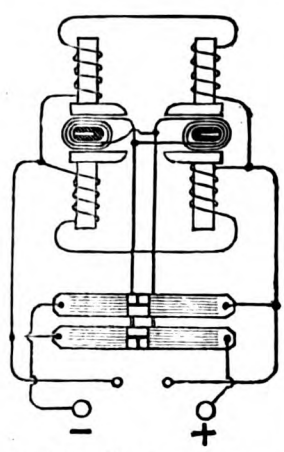

FIG. 7.—Connections for 20 amperes.

connections of the machine in the two cases. The effect on the resistance of the alteration from 10 to 20 amperes is to reduce it to a quarter of what it was, the internal loss, of course, remaining exactly the same as before; in fact, the power consumed and the work done in every part of the dynamo remains unchanged, the difference being one not of output, but only of the form in which the electrical power is delivered to the external circuit.

It is worth while to glance at the effect of this change in the form of the power, because it illustrates so well the cardinal fact of the practical economy of the method of working with small currents, a point which is now, happily, generally recognised. If it be required to light a given street with arc lamps, and to expend as loss in the leads not more than a certain percentage of the energy obtainable from the dynamo; and the choice rests between a certain number of 10-ampere arcs, or half that number of 20-ampere arcs, the section of the copper conductors in the latter case, and therefore their weight, must be four times as great for the latter case as for the former. This means in practice at least a fourfold increase in the cost of conductors in deciding in favour of 20 rather than 10 amperes.

The important question of the automatic regulation of dynamos is one which has recently attracted a great deal of attention, and deservedly so, since it is one of considerable importance. In the future the working conditions of circuits will be, to a much greater extent than in the past, varying conditions. Instances where the supply is required to be constant during the whole period of working, and where these requirements may be met by engines ordinarily governed, are becoming relatively rarer every day. Sensitive electrical automatic regulation of engine or dynamo, or of both, to supply the wants of varying circuits, are necessities of the great majority of the installations with which electrical engineers are now concerned. In a previous article* the writer dealt briefly with some of the conditions of this question, and gave a short account of the directions in which inventors had principally worked in their efforts to obtain automatic regulation. Leaving out of account regulation by alteration of speed, which is only practicable where a separate engine can be used for each circuit, and methods of winding or "compounding," which necessitate a steadiness of speed unfortunately by no means common, the conclusion arrived at bearing on the subject before us was that regulation "in series dynamos is best accomplished by

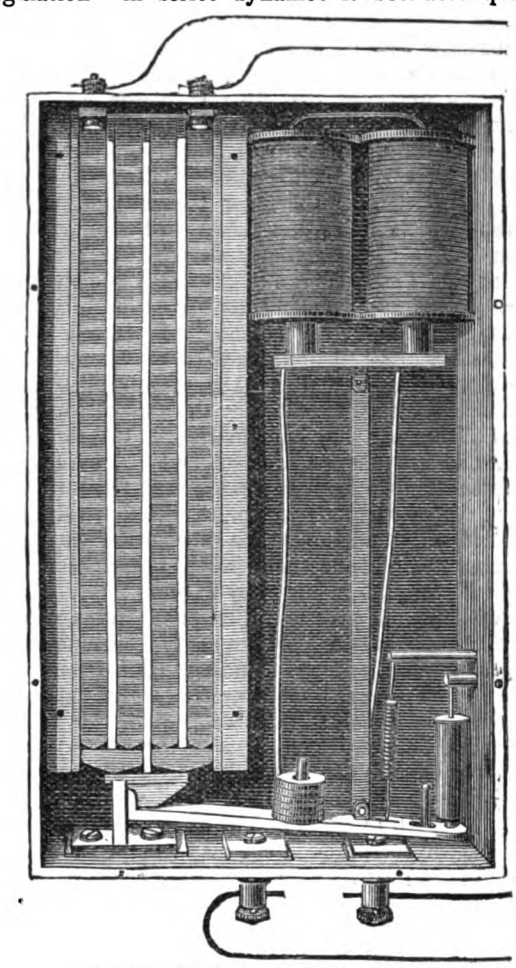

FIG. 8.—Brush Automatic Regulator.

employing a variable shunt placed across the terminals of the field magnet coil. . . . . The resistance should be capable of perfectly gradual variation, such as may be obtained by the compression of carbon, or by the use of a liquid resistance with movable electrodes." This principle has the advantage that it enables a saving to be effected in the work done in the field-magnet coils, as well as a reduction of any loss in the iron of the armature as the load is reduced.

The Brush Automatic Regulator, which is exhibited at the Corporation's stall in the East Arcade, is based on the above-mentioned principle. Fig. 8 illustrates the instrument used to regulate the No. 8 Brush dynamo, the new form of which supplies from 55 to 60 arc lamps in series. This instrument

* Supplement to *The Electrician*, July 31, pp. 22, 23.

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is very simple in construction. Two solenoids, which will be seen in Fig. 8 on the right, are placed in the circuit by means of the two terminals at the bottom of the case. Projecting into these solenoids are the two limbs of a U-shaped core of soft iron, which is attracted and drawn more or less into the solenoids when the current is passing. This iron core is connected by a long connecting-rod of brass to a lever of the second order, the fulcrum of which is a short standard provided at the top with a knife edge, on which one end of the lever rests. Near the fulcrum an adjustable screw (not shown), tapered to a point at the upper end, passes vertically through the lever, supporting a block which receives the weight of four parallel columns, each column consisting of a great number of thin plates of carbon about 1in. square. These columns are separated from each other by strips of slate, but at the top and bottom are connected by small slabs of carbon which join the four columns in series. At the top of the case are two screw terminals, to which are attached wires leading to the ends of the field-magnet circuit. These two terminals make contact respectively with two fixed blocks of carbon, against which, when the lever is raised by the action of the solenoids, the tops of the right and left carbon piles or columns press. A dashpot is provided for the purpose of checking sudden movements of the lever; and a spiral spring capable of being varied, together with some small weights placed on the lever, are used to facilitate adjustment of the instrument.

It will be observed that this regulator contains only a small number of parts, and is everywhere accessible for examination. Its action will be readily understood. When no current is circulating in the solenoids the lever is not raised, and in this position of the lever the piles of carbon do not touch the two fixed carbon blocks attached to the screw terminals. When the dynamo is working with a normal current, as when it is operating its full complement of lamps at full speed, or any smaller number at a suitably reduced speed, the strength of the solenoids is insufficient to raise the core and its attached lever, or only sufficient to very slightly raise them; and as the carbon piles under these circumstances are open-circuited by the gaps between them and the fixed pieces, the full current circulates through the field-magnets. But when lamps are switched out of circuit, or the speed of the dynamo from any cause is allowed to increase, a slight increase of current takes place, the core is drawn further into the solenoids, and the carbon piles are raised by the lever, being brought into connection with the upper terminals, which, as already explained, are joined by wires to the ends of the field-magnet winding. Thus the carbon piles are made to form a shunt on the fields. A portion of the current now passes through the carbon, and the field strength is thereby reduced until the normal current is again arrived at. The variation in the resistance of the carbon shunt necessary for the regulation of the current throughout the whole working range of the dynamo is obtained by means of the pressure exerted on the columns by the solenoid and its connected lever; this compression being automatically maintained at that which is necessary to give the proper excitation of the magnets for the requirements of the circuit. When from any cause the current tends to decrease, the core is slightly lowered, the pressure on the carbons is reduced, the resistance in consequence increases, as does also the field strength, until the proper current is obtained in the external circuit. Similarly, any tendency toward an increase of current, by a series of reverse actions to the above, is checked and corrected.

The use of a regulator of this sort is often a great convenience. In the case of the alteration of the number of lamps in circuit it is especially so, since it enables the dynamo to be run by an engine which is doing other work, and which on that account cannot have its speed altered. It is also very useful in maintaining a constant current with an irregular driving speed, in many cases enabling the electric light to be supplied in factories and other places where the employment of a separate engine for this purprse is objected to on account of its first cost, and the expense of attendance and maintenance. An exceptional case may be mentioned. A dynamo was supplied to be driven by an engine whose speed as a result of its special work varied in a regular pulsation to the extent of 40 per cent. The dynamo was to feed a certain number of lamps which were required to be steady. By so arranging the driving that, at the lowest speed of the engine, the machine was able to supply the proper current to the lamps, and by connecting an automatic regulator in the circuit, the difficulty was overcome, and the installation was successfully carried out.

Another point in connection with the Brush apparatus, and one which is attracting some attention at the present time, is the peculiar construction of dynamos for the electro-deposition of metals patented seven years ago by Mr. Brush. We are not concerned in this article in any question of patent rights or priority of invention; but it may be interesting to examine into the character of the effects produced in these machines, especially as, so far as the writer is aware, no results of electrical tests have hitherto been published.

It is doubtless well known that the Brush electro-plating dynamos have for some years been constructed on the principle described in the patent alluded to above, which is now known as "compound-winding." That is to say the field-magnets have been wound with two wires, one a conductor of large section, connected, as is customary in series dynamos, in the main circuit in series with the armature and external circuit; the other a comparatively long and fine wire known, according to the American technical phraseology, as a "teaser"—connected directly to the brushes as is usual in shunt machines, or, as a modification, to the terminals of the machine.

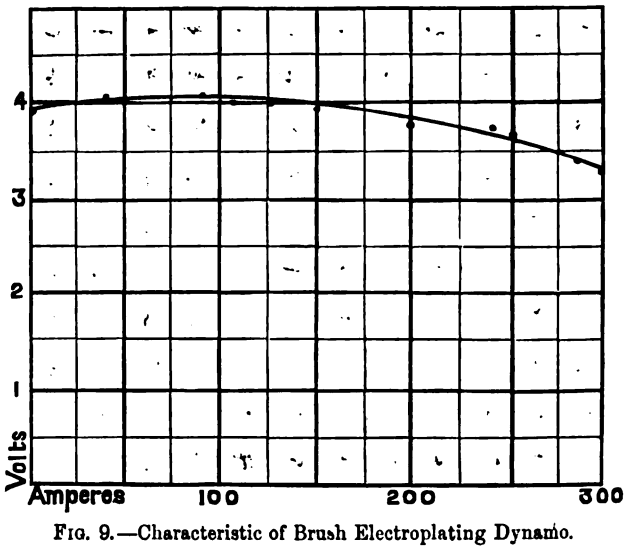

FIG. 9.—Characteristic of Brush Electroplating Dynamo.

One of the objects of this mode of construction, as stated in the patent specification, was to enable the dynamo to do either a large or small amount of work. Now in an electro-plating bath, where all the articles to be plated are connected parallel, the requirements of the case demand that the difference of potential between the electrodes should be as nearly as possible constant, in order that the character of the deposit may be uniform, however the number of articles in the bath may vary; or, in other words, whatever the amount of current flowing. This constancy of potential was not then even approached with shunt machines nor with series machines, which latter are also objectionable on other grounds for this kind of work. The two systems of winding will, however, in combination produce the required results, as is now perfectly well known.

Fig. 9 is the "characteristic" of a small Brush plating dynamo, intended for the deposition of copper, manufactured several years ago. This curve shows that, although the machine might not compare favourably with the latest results obtained in compound winding, its maker had succeeded to a remarkable extent—considering the period—in preventing the great variation of potential which would have been caused by alterations of the load in the machines as ordinarily constructed. Indeed, there are many "compound" dynamos in use, constructed even within the last two years in this country, which are characterised by curves no better than that of this old American plater.

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NOTES.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 2nd inst. amounted to £3,148.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ending 30th September amounted to £3,680.

PERSONAL.—Advices from Cairo state that Mr. Floyer, Inspector-General of the Egyptian Telegraphs, returned on the 6th inst. from the recent Telegraph Conference at Berlin.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of September were £1,770, against £1,663 in the corresponding period of last year.

THE NORTH WALES UNIVERSITY COLLEGE.—Particulars will be found in our advertisement columns of the departments of Physics, Chemistry, and Biology at this College for the Session 1885-86.

THE OATH OF SECRECY.—A few days before the inauguration of the "Tannergram" fifty lads were marched into the Thames Police-court, London, for the purpose of being sworn in as telegraph boys.

SUBMARINE CABLES TRUST.—This trust give notice that the coupons due on the 15th inst. will be paid on and after that date by Messrs. Glyn and Co., between 10 and 2. The coupons must be left three days for examination.

THE EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of September amounted to £41,845, against £41,590 in the corresponding period of 1884; increase, £255.

GREAT NORTHERN TELEGRAPH COMPANY.—The receipts of this company for September amounted to £25,200; from 1st January to 30th September, £217,240, against in the corresponding months of 1884 £208,680, and 1883, £191,880.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 2nd October, were £2,451, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

SCHOOL OF ART AND SCIENCE, READING.—The annual distribution of prizes will take place this (Friday) evening, in the New Town Hall. Mr. J. Walter, M.P., the president, will occupy the chair, and Mr. W. H. Preece, the chief electrician at the Post Office, will deliver an address.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 30th September are £1,849, as compared with £2,009 in the corresponding period of 1884. The June receipts, estimated at £5,860, realised £5,945.

ELECTRIC LIGHTING IN NEW ZEALAND.—Messrs. Fletcher and Co., electrical engineers, Dunedin, are fitting up the Mosgiel Factory, Wellington, with a Victoria dynamo for 300 lamps, which will be the largest incandescent installation in the colony. Messrs. Fletcher and Co. are also fitting up the Roslyn Mill with the electric light.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of September was 2,582, estimated to produce £2,100, against 2,645 messages, producing £2,163 in the corresponding month of last year. The traffic receipts for the month of June, estimated at £3,000, realised £3,032.

THE DIRECT UNITED STATES CABLE COMPANY.—The Board of Directors of this company resolved, on the 2nd instant, upon the payment of an interim dividend of three shillings per share, being at the rate of three per cent. per annum for the quarter ending 30th September, 1885, such dividend to be payable on and after 24th inst.

THE ELECTRIC LIGHT BROUGHT HOME TO US.—Under the above title a penny *brochure*, evidently issued by the Anglo-American Brush Electric Light Corporation, gives much practical information on the somewhat difficult subject of domestic lighting. The little work is written in a very popular manner, and should find favour with the public.

THE SOUDAN TELEGRAPHISTS.—It is officially notified that the under-mentioned non-commissioned officers and men attached to the 24th Middlesex (Post Office) Rifles have been "specially commended" for the good service rendered by them as telegraphists during the late campaign in Egypt and the Soudan:—Sergeant J. Parrish, Lance Corporal J. Hopgood, and Sappers A. Isles and W. C. Tee.

THE TELEPHONE AT SHANGHAI.—Not long ago the Telephone Exchange at Shanghai was connected with the band stand in the gardens, a swinging transmitter, placed near the ceiling of the stand so as to be out of reach, being used. The music was heard, we are informed, with great distinctness in the office of the China and Japan Telephone Company, which is situated at some distance from the gardens.

GENERAL GORDON'S TELEGRAPH.—According to Major Kitchener's "Notes on the Fall of Khartoum," General Gordon had a complete system of telegraphic communication with all the posts along the line of fortifications, and there must, says Major Kitchener, have been great irregularity in the telegraph stations to account for his being left entirely unwarned of the attack and entry of the rebels. Doubtless Farag Pasha was responsible, to some extent, for this.

ANGLO-AMERICAN TELEGRAPH COMPANY.—At a meeting of the Board of Directors of this company, held on the 2nd inst., it was resolved, after placing the sum of £25,000 to the renewal fund, to declare an interim dividend for the quarter ending 30th September, 1855, of 5s. per cent. on the ordinary stock, and 10s. per cent. on the preferred stock, less income-tax, payable on the 31st October to the stockholders registered on the books of the company on the 30th of September, 1885.

"TANNERGRAMS" AT HULL.—The Post Office officials having declined to continue the delivery of telegrams at the Exchange, instead of at the regular place of business of the addressee, unless porterage to the amount of sixpence be paid, an indignation meeting has been held and resolutions passed condemning the action of the authorities. The meeting was of opinion that the authorities should consider it a privilege to be permitted to deliver messages at the Exchange. Suppose the authorities are content to waive the privilege?

A "TANNERGRAMMER" IN TROUBLE.—A correspondent of *The Times*, who resides in the verdant locality of Lincoln's-Inn-Fields, bewails the fact that accident of location mulcts him comparatively of the sum of one penny every time he sends a "tannergram." He takes exception to the fact that by living at a polysyllabic district within a township he has to devote one-third of his telegraphic income to the State. Redress is, however, procurable. Let him take comfort and a house in Oldham-cum-Newton-le-Willows, and the tables will be turned.

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INTERESTING ARTICLES.—In the current number of the *Philosophical Magazine* Prof. Oliver Lodge continues his very valuable remarks on the "Seat of the Electromotive Forces in a Voltaic Cell," and discusses the theories of Wiedemann and Helmholz. Some notes upon the same subject by Dr. J. Hopkinson also appear in the same number. Owing to the pressure upon our columns we are compelled to withhold these articles for the present, but as they are supplementary to Prof. Lodge's former paper, which our readers will remember we published *in extenso*, we shall deal with them at an early date.

THE "EXMOUTH" TRAINING SHIP.—The installation of about 150 lights, which is being put down by Messrs. R. E. Crompton and Co. on board this ship, is rapidly approaching completion. The "Exmouth" is moored in the Thames, off Grays, and on Tuesday last the cable to connect the ship with the engine and dynamo rooms on shore was successfully laid. During the laying operation, which was witnessed by Mr. Albright, of the firm of Crompton and Co., and Mr. Phillips, of Phillips Brothers, who have supplied the cables, valuable assistance was lent by the chief officer of the "Exmouth," and a number of the lads under his command.

THE EASTERN TELEGRAPH COMPANY.—This company announce the payment on the 15th instant of a dividend of 3s. per share on the preference shares of the company, less income tax, for the quarter ended 30th September, 1885, and that an interim dividend of 2s. 6d. per share in respect of profits for the quarter ended 30th June, 1885, on the ordinary shares of the company, free of income tax, will be paid on the same day. The register of transfers will be closed from the 8th to the 15th October instant, both days inclusive.—The traffic receipts of this company for the month of September amounted to £47,849, against £50,913 in the corresponding period of 1884.

SOIREE AT GUY'S HOSPITAL.—A soirée took place at the above hospital on Thursday last, the rooms being very beautifully lighted with Woodhouse and Rawson's incandescent lamps, worked off Faure-Sellon-Volckmar accumulators, delivered on the morning of the soirée. The installation was a very scattered one, 900 yards of main lead alone being used. The rooms lit were as follow:—The Museum of Comparative Anatomy was lighted by twelve 20 candle-power lamps, and the new Museum was given nine 20 candle-power lamps, while the entrance hall and staircase were very prettily lighted with suspended lamps, floral wreaths being used to form festoons from which the lamps hung.

ELECTRICITY AND CALCULATING MACHINES.—Electricity has recently been applied to the working of calculating machines by an enterprising American inventor. The record is shown on dials somewhat in the same manner as on the street car conductors' register, except instead of making nine motions to register 9 units, one movement only is required, and the movement of the dials is effected by electricity instead of by cogs. The perfection of the device is such that on the machine in the Massachusetts Census Office, in Boston, which has nine dials, the addition of one unit to the registered number 999,999,999 sets all the dials at zero, so that if there was another dial the record would be 1,000,000,000.

ELECTRICAL GAS-PRESSURE ALARM.—At a recent meeting of the Midland Association of Gas Managers, Mr. Tindall showed in action one of Bishop's electrical gas-pressure alarms, made by the Walsall Electrical Company. This apparatus is suitable for use in the exhauster-house, where any undue vacuum or back pressure is at once signalled in an unmistakable manner, and on the matter being righted the appliance is at once ready for action again. If fixed in the purifier-house, the rise of back pressure beyond a determined point is similarly rung out. Floats are placed in the tubes of the gauge, and while serving to distinctly show the water-levels, make the electrical contact at any desired point, and thus ring a bell, which, of course, can be placed in any position, and, if desired, drop an indicator, showing that the bell has been in action during the manager's absence.

CITY AND GUILDS OF LONDON TECHNICAL COLLEGE, FINSBURY.—The inaugural dinner of the Old Students' Association took place at the Manchester Hotel, on Thursday, the 1st inst., when over forty sat down to dinner. The company included Prof. S. P. Thompson, D.Sc., principal of the college; Prof. Perry, F.R.S., Prof. R. Meldola, Prof. Armstrong, F.R.S., and Messrs. Walmesley, Blaine, Adams, and others. A very pleasant evening was spent, and excellent speeches were made by Prof. Thompson, Prof. Perry, Prof. Meldola, Prof. Armstrong, Messrs. H. L. Lawrence, A. Chatterton, and others. Mr. H. L. Lawrence was elected president for the year, and Mr. A. C. F. Webb, hon. sec. Besides the forty-one present at the dinner, as many more have promised to join the association. We understand the first business meeting will take place at the College, Leonard-street, on Friday, November 6th, at 7:30 p.m.

UNIVERSITY COLLEGE, LIVERPOOL.—We have received the prospectus of day classes on art and science, and evening lectures, for the Session 1885-6, in connection with the above college. The academical year consists of three terms, Autumn, Lent, and Summer. In the year 1885-6, the Autumn Term commences October 5th, and ends December 19th; the Lent Term commences January 11th, and ends March 27th; and the Summer Term commences April 28th, and ends July 8th. During vacations, and also on Whit Monday, the college will be closed. At the commencement of the Autumn Session there will be a public meeting in St. George's Hall, at which the award of medical scholarships will be published and the medical school prizes be distributed to the successful students. The college provides day and evening classes, both of which are open to male and female students alike. The classes of the medical faculties are open to male students only. No person under fifteen years of age will be admitted as a day student, and all under sixteen will be required to pass a preliminary examination previous to admission. The Chair of Engineering is occupied by Prof. H. S. Hele Shaw.

L'ECOLE DE TELEGRAPHIE, PARIS.—The list of preparatory courses at L'Ecole Supérieure de Télégraphie, Paris, for the scholastic year 1885-86 has been issued. The candidates are to be between the ages of 20 and 30 years, and to be *employés* of the Posts and Telegraphs, with not less than two years' service in their special grade; or ex-pupils of one of the following schools:—Ecole Polytechnique, Ecole Normale, Ecole des Mines, Ecole des Ponts et Chaussées, Ecole Forestiére, or Ecole Centrale des Arts et Manufactures, having duly graduated. The subscription is to be 1,800 francs per annum. The courses are very comprehensive. The students will be given facility to study electrical work of all kinds, including submarine telegraphy, not only at the school itself, but in such workshops and cable stations as may be selected by reason of their great practical efficiency. After having passed through the courses and satisfied the examiners, the students will be admitted into the Government telegraph service in the capacity of junior electrical engineers. We consider this a most excellent project, and must congratulate M. Cochery upon the valuable scheme he has formulated. Such a school should add to the prosperity of France.

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HUMAN ELECTROTYPES.—*The Scientific American* ventilates a somewhat ghastly idea evolved by M. Kergovatz, a chemist of Brest, who has proposed a new method of disposing of the human body after death. His system is an antiseptic one, much simpler and less expensive than the old process of embalming, and is nothing more than a new galvanoplastic application. The body is coated with a conducting substance. such as plumbago, or is bathed with a solution of nitrate of silver, the after decomposition of which, under the influence of sunlight, leaves a finely divided deposit of metallic silver. It is then placed in a bath of copper sulphate, and connected for electrolysis with several cells of a gravity or other battery of constant current. The result is that the body is encased in a skin of copper, which prevents further change or chemical action. If desired, this may be again plated with gold or silver, according to the taste or wealth of the friends of the dead. M. Kergovatz has employed the process eleven times on human subjects, and on many animals, and states that in all cases it was perfectly satisfactory. In spite, however, of his warm recommendation, the idea is repulsive. It seems a mockery to give permanence to the temple, when all that once made it valuable is gone.

COMPOUND WINDING.—Some surprise has been manifested that we have not hastened to comment upon the present position of the patents relating to compound winding. Although not arrogating to ourselves the position of elevated beings, we certainly think that those who can so easily (to their own satisfaction) determine the present position of parties partake somewhat of the character of the other beings referred to in the old adage. We shall not be surprised to find that those most interested in the matter will agree that it is not wise to test the validity of any patent. The mere fact that a disclaimer has been allowed does not make a patent valid. The proving of a patent invalid may throw open a process to the whole world. The validity of a patent is a complicated question, and one that cannot be decided by the off-hand remark that "this has been patented before." We should advise those who are at all interested in patents to keep beside them the "Abridgments of Specifications," issued at the Patent Office. The price of Part II., A.D. 1867–76, is one shilling, and this contains on its last page the abstract of Varley's specification, which has been said to cover "compound winding;" but we also think a closer examination of these and other volumes of abstracts will open the eyes of many who imagine recent patents contain new ideas, new discoveries, and new combinations.

THE TELEPHONE IN SHEFFIELD.—On Sunday two interesting experiments were made in Sheffield with the telephone. That day harvest festival services were held in St. Paul's Church, Manningham, near Bradford, and with the object of exhibiting the powers of their telephone, the National Telephone Company extended their wires between Sheffield and Bradford to the church. During each service there was a number of persons at the local office of the company listening to the proceedings, the choral part of which they heard almost as distinctly as if they had been in the church itself. Three "Blake" transmitters have been introduced in the church, one being placed in the pulpit, another on the reading desk, and the third on the lectern. There are permanent fixtures to enable invalids and others to listen to the services from their residences on any Sunday, a kind of advantage which, although promised when the invention was brought before the public, was scarcely expected to be realised by many people. Notwithstanding the number of telephones attached to the two wires employed, the power of sound reproduction was strong in Sheffield, and not only were anthems and hymns clearly heard, but the voice of the clergyman came out well at times. Conversation with the telephone managers was easily carried on, and even a a laugh at the Sheffield office was audible to the Bradford agent.

NEW ZEALAND INDUSTRIAL EXHIBITION.—An Industrial Exhibition was recently opened in Wellington, New Zealand. Amongst the electrical exhibits Messrs. R. E. Fletcher and Co., electrical engineers, of Dunedin, had a varied collection of interesting apparatus for electric lighting. In addition to three arc lamps, which were suspended from a mast 100ft. in height, several suites of rooms in the drill shed were also lighted up by the same firm. Some of the fittings used for the Swan incandescent lamps were of a very ornamental character. One of the most interesting exhibits in the building was a working model of Prof. Fleeming Jenkin's telpherage system. The model at the Exhibition is actuated by a miniature dynamo, and this dynamo was driven by a small water motor. Another interesting exhibit was a model tramcar, which ran upon an elliptical track in the court yard. The combination of water-power with electricity must have an important bearing on the future of New Zealand. Already Messrs. Fletcher and Co. are using two Felton wheels in the Lake County, Otago, the electricity being transmitted two miles and used for working quartz crushing machinery. Dr. Hector, in conjunction with Mr. Prince (late electrician to the Union Company, but now a member of the firm of Fletcher and Co.), delivered a lecture on the telpher system of communication during the Exhibition.

THE "VRIL" STICK.—Those who have read the "Coming Race" will at once grasp the wonderful possibilities offered by the following novel invention. It is scarcely necessary to say that a non-technical contemporary is responsible for the account of it:—"One of the latest applications of electricity is an invention made in the interests of lion tamers, which consists of an apparatus of great power, shaped like a stick, about 3ft. 6in. in length. M. Rauspach, the inventor, is a lion tamer himself, who has been a 'good deal worried' during a long and successful career. He has already experimented with it upon the denizens of the cages in his menagerie, and relates the different effects upon the brutes. Three of his lions receiving the shock immediately showed signs of the greatest terror. They were seized with trembling, and growled fitfully. The tiger was more quickly subdued, became stupefied, and crouched in a corner of the cage. Bruin was more refractory to electricity, which seemed scarcely to affect him. He would growl and show his teeth, but was subdued after repeated discharges. The most astonishing effects, however, were perceptible in the boa constrictor. On receiving the discharge the specimen from Cayenne, nearly 20ft. in length, became at once paralysed, and remained motionless for six hours afterwards. When he recovered he showed signs of helplessness for three whole days. Finally, the elephant, on being electrified by a touch of the stick upon the tip of his trunk, set up a series of wild cries, and became so strange that the tamer feared the brute would break his heavy iron chain."

BLUNDERS IN TELEGRAMS.—A correspondent of the *Standard* says:—"If I may trespass a little on your valuable space I should like to bring before the public a matter which is not, I believe, at present widely known. A short time since I sent a cable message to my sister, in Massachusetts, to this effect:—'Can receive you in Wales.' The message was transmitted, 'Can't receive you in Wales.' It would be impossible to describe the confusion and annoyance caused by this careless

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error. Yet I am informed by the Postal Authorities that I can get no redress because the conditions applying to foreign messages were not adhered to. These conditions necessitate an extra payment (of about half the original sum paid for the message) to insure accuracy. This arrangement is, I believe, unknown to the majority of the public, although it is printed in the "Postal Guide." Still, as very few people have time to refer to this interesting publication before despatching a telegram, it seems as if the least that can be done is that the Post Office official should refer the sender of the message to these conditions. If a tradesman sells you an inferior article, or you suffer annoyance from any of his *employés*, he is willing at once to make you all the reparation in his power; yet in a matter of far greater importance the Post Office authorities decline all responsibility with regard to the accuracy of a message in its transit. Surely this calls loudly for investigation and amendment. Either the charge for foreign messages should be raised to an amount that will ensure accuracy, or the public should be informed that they must not expect their messages to be correctly transmitted."

CONTINENTAL ITEMS.—The students of the new lycée Louis-le-Grand in Paris have expressed their warm appreciation of the installation of 400 10 candle-power incandescents recently put down in the building by the Edison Company.—Under the heading of "Saint-Etienne at the Head of Industrial Progress in France," the *Echo des Mines* protests against the impression which has been gaining ground that the provincial towns of France are hostile to anything approaching innovation. They would all like the electric light, but don't want to bestir themselves. Human nature is human nature all the world over.—The French Academy of Medicine has received from Dr. Brondel a communication upon the economic preparation of medicines by dielectrolysis.—The Belgian Electrical Society are about to conduct a series of experiments with a new electric launch in the basin attached to the Antwerp Exhibition. It is expected that the launch will attain to a speed of over nine knots an hour.—Mr. Guilleaume, of the firm of Felten and Guilleaume, has left Cologne for Paris with a view to procuring the adoption of his anti-induction cables for the State telephone lines.—The French Minister of Posts and Telegraphs expects to open shortly the telephone lines between Paris and Reims.—The Gallerie De-Cristoforis in Milan is to receive an installation of the electric light, to be put down by the Edison Company.—The St. Petersburg journals state that a Russian named Stepanow has invented a new primary battery that will give us the electric light at a cost of 10 per cent. less than that of gas. The fun of it is, however, that the Stepanow battery is a *modification of the Daniell.*

ANOTHER FACSIMILE TELEGRAPH.—A contemporary says that a correspondent, writing from Toronto, has forwarded information of a further extraordinary invention in the domain of electricity. This consists of nothing less than the transmission of handwriting. The inventor is a young man of only some 24 years of age, and it is his intention to offer his discovery in the first place to the British Government, whose acceptance it would, it is assumed, be an absolute test of its value in practice. The method of transmission is something like the following:—"On a strip of foil the writing is traced with any common ink to which an acid has been added. The acid bites into the foil, which is then, after being dried, put on a drum and an electric needle made to work rapidly across every part of the foil. At the other end of the wire a similar needle and drum are placed in circuit, and the result is the *vera effigies* of the writing. The process has been worked well up to a distance of 130 miles in America, and it is believed that a like success would be obtained over any distance. Its uses are not, it can be understood, restricted to caligraphy. The electric needles will reproduce all lines engraven on the foil, so that designs and drawings will be telegraphed. The inventor claims for this method of telegraphy an important economic value, as the direct transmission of the handwriting of the senders of messages will be effected with no intervention of the human intelligence to interpret the written language by means of arbitrary telegraph signals." There is nothing extraordinary in this invention as far as we can see, and it certainly is not new. The process is undoubtedly a very slow one, and is probably expensive. We shall be surprised if we hear of its practical application for other than experimental purposes.

THE NEW PERSIAN GULF CABLE.—The ss. "Dacia" sailed from Greenhithe on Tuesday afternoon with a portion of the new cable for the Persian Gulf section of the Government Indo-European Telegraph. The rest will follow in the ss. "International" to-day (Friday). The expedition is under the personal direction of Colonel Bateman-Champain, R.E., Director-in-Chief of the Indo-European Telegraph Department, assisted by Sir Henry Mance, electrician of the Persian Gulf section, and a competent technical staff. The new cable is intended to strengthen the weakest portion of the Indo-European system, viz., the section from Jask, near the mouth of the Persian Gulf, to Bushire. From Kurrachee to Jask there is a land line as well as a submarine one, and from Bushire to England there are two distinct lines, one (the Indo-European) through Persia, Russia, and Germany, and the other *vid* Bussorah, Bagdad, and Constantinople. While there are thus alternative lines at all other parts of the Indo-European system, the Jask-Bushire portion depends entirely on submarine cables, of which there are at present two—one laid in 1864 and the other in 1868. From age both have long been in a dangerous condition, and in need of constant repair. The question, therefore, arose whether this weak section should be strengthened by a new cable or by a land line from Jask to one of the stations in Persia—Shiraz, for instance. The former course was decided upon last May, and the present expedition is the result. The new cable is 530 miles in length. Including the expense of laying, it will cost £80,000. Among those who assembled at Greenhithe to wish the expedition God speed were Mr. Juland Danvers and Major Jopp, R.E., of the India Office, and Colonel Murdoch Smith, R.E., Director of Persian Telegraphs.

ELECTRICAL TRANSMISSION FROM NIAGARA.—There appears in the current issue of *The Electrical Engineer* an interesting article which treats, under above title, of the Falls of Niagara as a source of power. The power of Niagara can be estimated very approximately. The average flow of the river, according to the many careful measurements of the U. S. Lake Survey, is 275,000 cubic feet per second. The fall in the river through the rapids immediately above the Falls is 65ft., height of the Falls 165ft; total, 230. Then we have the whole power: $\frac{275{,}000 \times 230 \times 62}{550} = 7{,}000{,}000$ horse-power. To utilise this amount of power by water wheels, generate electrical currents, and transmit to various cities within 500 miles, would necessitate a plant representing at least five thousand million dollars. Such figures as these give some idea of the enormous amount of power here in reserve. In order to transmit currents of electricity profitably to a distance several conditions must be observed:—1st. The cost of transmission must be less than the difference between the

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cost of steam and water power. 2nd. The distant point must be one where the currents of electricity can be used; and 3rd. Where water-power cannot be obtained. The author selects the city of Buffalo as the point most likely to fulfil these conditions, and in an estimate based upon the Brush system, with which he is most familiar, goes on to show that the total cost per horse-power of power delivered in Buffalo would be 20 dollars (£5) per annum. In comparison with steam as the source of power the saving would, he thinks, on a plant of 1,000 arc lights, be about 40,000 dollars yearly.

MR. CAMERON ON CHEAP TELEGRAMS.—To the *Fortnightly Review* for the current month Dr. Charles Cameron, M.P., contributes a paper reviewing the history and prospects of the Sixpenny Telegram scheme which came into operation on the 1st inst. He entertains no doubt as to the financial success of the new tariff, and regards it only as a preliminary to a still more popular one. With vigorous and careful management the telegraph system of the country is capable, he believes, of a great developement, "in which the introduction of the sixpenny tariff can only be regarded as a first step." He proceeds then to indicate the sort of measures and management likely to contribute to this development. Contrasting our system with that of France and Australia, he points out that in the latter countries a form is in use which enables the receiving clerk to write the name and address of the addressee on a flap which can be folded over and sealed for delivery without further trouble, the operator in fact handing it fastened up to the sending-out clerk ready for delivery. The message as well as the address in these countries is, it appears, written with ink. Mr. Cameron's second suggestion is that the fee for registration be reduced from 20s. to 2s. 6d. or 5s., and he points out that in America the companies register the addresses of their "more important clients" free of charge. In order, however, to recoup the revenue for any immediate loss caused by the reduction of the general tariff, Mr. Cameron insists that the telegraph system "must be worked to its fullest capacity;" and to accomplish this he recommends the adoption of the Belgian plan of express messages, or that which prevails in India, where three classes of messages, ordinary, deferred and express are permitted. To increase the traffic of the "ordinary" kind he would reduce the tariff still further by one-half; or, if that could not be done, he would double the maximum number of words allowed for this class of telegram, thus insuring, as he predicts, the full occupation of all the wires to all places. Further, he would utilise the "idle" wires for the convenience of commercial men, who might be allowed to hold conversation with each other on any idle telegraph circuit at a charge of £1 per hour. Lastly, he urges greater publicity to the permission to drop telegrams into letter boxes, a system which has utterly failed, simply because, as he thinks, the public are not aware of the privilege. We shall take an early opportunity of discussing these, Mr. Cameron's, ideas of telegraphic development.

ELECTRICITY AND MINING.—The first lecture for the session 1885-6, in connection with the Durham College of Science Newcastle, was delivered on Saturday afternoon, in the theatre of the Literary and Philosophical Society, by Prof. Merivale, who, in the course of his address, said that electricity was not a substitute for coal. Coal was a *source* and electricity a *form* of energy—very different things. He would first of all show that by means of a magnet they could produce a current of electricity, and also the converse—that by means of a current of electricity they could produce a magnet. All the practical applications of electricity depended upon these two facts. The dynamo was merely a magnet moving in the neighbourhood of a coil of wire, or a coil of wire moving in the neighbourhood of a magnet. He then referred to appliances which would assist the mining engineer. A serious danger to the miner arose from the presence of fire damp. Ten years ago people were under the impression that unless there was 6 per cent. of gas present there would be no explosion. The Davy lamp detected 3 per cent.; but it had been discovered that 1½ per cent. of coal damp could cause an explosion, and, therefore, no dependence could be placed upon the Davy lamp to find the presence of coal damp sufficient to cause an explosion. The electric current in Ansell's fire damp detector was affected by gas in sufficient quantities to cause the risk of an explosion. Liveing's detector glowed in the presence of gas according to its density, and, to prevent it from causing an explosion, the flame was enclosed in gauze. The lecturer said electric light seemed to afford every possible safety, because the light, burning in a vacuum, could not possibly cause an explosion. MM. Benoit and Dumas had patented one lamp, the difficulty with which, however, was in supplying sufficient electricity for the various purposes of the mine. Mr. Swan had lately brought out a portable miners' light which he (Prof. Merivale) hoped would succeed. The difficulty was in getting a portable battery. He was glad to show them a patent magnetic lock, providing against the danger of miners unlocking their lamps. They could not unlock this one without a very powerful magnet, and the lamp was relighted without opening it. The electric light was exceedingly convenient when placed upon coal screens, and also for lighting the workings in the neighbourhood of the shaft. It gave a far better light than either gas or oil, and was both safer and cheaper. The light which he exhibited was obtained by the "shunt" dynamo heating the platinum wire. A couple of wires, having two lights suspended from them, were stretched along. There were sundry subsidiary wires, and all that was required, was an engine to turn the dynamo. They now came to consider how they could get the coal more readily and more cheaply by means of electricity and magnetism. The earliest adaptation was the compass. After the compass came, undoubtedly, the different methods of signalling by electricity. When they considered the great inconvenience of signalling in the old way—and he was sorry to say the way which they still found in a great many collieries—the wonder was that a simpler method, such as by electricity, did not come in sooner. The lecturer then explained the single wire system, and the double wire system, showing a model of a pit and the working of the bells in signalling the point of contact with the wires. Another subject of interest was the distribution of carrying power in mines, making large quantities on the surface and transmitting it below into the different districts. He hoped that some day electricity would be used for this purpose, but, at present, the only appliance that they knew was air compressed at bank. They had, however, to consider that they got not above 30 per cent. of the power they were expending at bank, while in the case of electricity they could get something like 70 per cent. of the power put in at the surface. If distribution of electric power were needed, they would have to transmit it to each district by means of resistance wires and regulators. Prof. Merivale then exhibited a few working models to illustrate how electricity could be used in mines. The experiments concluded with an electric locomotive being driven quickly round a circular railway, and the lecturer stated that such traffic in pits was perfectly possible, and he had no doubt would be more economical than the present system of hauling, in which they had to use long and heavy ropes, and, of course, supply the motive power.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 307.)

Magnetic and Electric Comparisons.

(*a*). Let two large masses of iron be united by a thin iron wire. For simplicity of exposition let the two masses and the wire be homogeneous throughout, and only "elastically" magnetisable. Call the masses P and Q, and the wire *w*. Let air surround them to a great distance, to get rid of foreign influences. The masses may be conveniently imagined brought near one another, and the wire not to join them straight, but to be led round through the air, although these assumptions are immaterial.

Now let a portion of the wire, which we shall call *x*, be intrinsically magnetised to intensity I parallel to its length. Here, again, we may conveniently imagine *x* to be very short, to be a mere disc, in fact, perpendicular to the axis of the wire. The magnetisation I is the same as an impressed magnetic force *h*, similarly distributed, if $I = \mu h/4\pi$, and μ is the permeability of the iron. Instead of this impressed force in *x*, we may equivalently have an electric current round *x*, say in a coil of very small depth. Or, instead of this real current, we may refer to a false electric current round *x*.

The magnetic induction passing through *x* due to *h* (or its equivalents) is both altered in amount and in distribution from what it would be were *x* alone in the air. Its amount is increased by the permeance of the magnetic circuit being increased. And its distribution is altered, on account of the permeability being changed unequally in different places. It is, to a certain extent, led along the wire to the mass P (of course with a large amount of leakage on the way), through the air to Q, and through the wire back to *x*, completing the circuit. But if we increase the permeability of the iron we increase the induction, and at the same time cause relatively more of it to pass through P and Q, with relatively less loss from the wire (out on one side of *x* and in on the other). Indefinitely increase the permeability. The total induction in the circuit reaches its greatest value. The leakage becomes relatively insignificant, and by making the wire thinner may be reduced indefinitely. Thus nearly all the induction is led through the wire to P, through the air to Q, and back to *x* through the wire. The total induction depends on the form and relative position of P and Q (with which, to be exact, we must count the two portions of *w* on opposite sides of *x*). In this final state the magnetic force in the air is everywhere perpendicular to the surface of P, Q, and *w*, except at *x*, where it is partly tangential.

(*b*). Replace the iron by a solid dielectric non-conductor of high electric capacity or low electric elasticity. Replace the impressed magnetic force *h* by impressed electric force *e*; or by intrinsic electrisation of intensity $J = ce/4\pi$, if *c* is the electric capacity; or, finally, by a magnetic current round *x*, similar to the before-used electric current, except that it must circulate the reverse way. The flux is now elastic electric displacement. Its distribution is similar to that of magnetic induction in (*a*). On indefinitely increasing *c*, or doing away with the electric elasticity in the solid dielectric, the greatest displacement is obtained. It then passes through the air mainly from P to Q. The electric force in the air is normal to the surface of the solid dielectric, except at *x* again.

(*c*). If in the case (*b*), before making the capacity infinite, and when, consequently, the final state (*b*) is not assumed, we communicate to the solid dielectric throughout its whole substance any finite degree of electric conductivity, we shall cause the displacement in the air to immediately (practically) assume the final state (*b*). The conductivity may vary anyhow, and likewise the electric capacity, which last may in fact be zero now. This is the common case of charging a condenser, except that it is usual to consider the conductor as having no electric capacity.

(*d*). If, in the case (*a*), of magnetic induction, we could communicate to the iron any finite degree of what, by analogy, we may call magnetic conductivity, rendering it impossible for the iron to support magnetic force without a magnetic conduction current, with dissipation of energy, it would be unnecessary to make the permeability infinite to obtain the final distribution in the air there mentioned. The permeability might be finite or zero, and the magnetic conductivity have any distribution in the iron. The final state would be as in (*c*), with magnetic induction instead of electric displacement. The examples (*a*), (*b*), and (*c*) are real, except as regards the assumption of infinite values of μ and *c* in (*a*) and (*b*) respectively, which may be conveniently imagined to become very great, though not really infinite, thus letting us approximate to the required results without using impossible conceptions. The example (*d*) is unreal. It is introduced to show the analogy.

In examples (*b*) and (*c*) the displacements out from P to the air, and in from the air to Q are identical. (The final state (*b*) is referred to.) But there is no electrification in case (*b*), whilst there is in case (*c*). If in case (*b*) we remove the wire from P and Q to a distance, we shall at the same time do away with the former apparent charges of P and Q. There will be left merely the small displacement from the wire on one side to that on the other side of *x* where the impressed *e* is, some small part of which will of course go through P and Q *viâ* the air. But if, in case (*c*), we remove the wire, P and Q will be left charged as before; besides that we have an insignificant wire charge. Herein lies the difference between elastic and conductive displacement.

Similarly, if in the example (*a*) we remove the wire from P and Q, we at the same time do away with their apparent magnetic charges. Whilst, if we could realise the case (*d*), on removal of the wire the bodies P and Q would be left really charged magnetically. They would apparently be unipolar magnets, though without any interior polarisation, it being a matter of the terminal induction of the medium between them. In the final states of (*a*) and (*b*) there is finite interior induction or displacement, being the exact complements of those outside in the air, although there is no interior magnetic or electric force, and consequently no interior magnetic or electric energy. But in examples (*d*) and (*c*) having the same external induction or displacement as in (*a*) and (*b*), we have no interior induction or displacement as well as no magnetic or electric force and no interior energy.

(*cc*). Going back to (*c*), with an impressed electric force in the wire, let us join P to Q by a second conducting wire, attaching it to them anywhere, but for distinctness, away from the first wire. We shall now have a steady conduction current in the closed circuit made, as well as elastic displacement in the air, having a different distribution to the previous; the amount of change depending materially upon the resistance of the second wire compared with that of the rest of the circuit, being small when it is great, and conversely. The electric force is no longer normal to the conductors at any part of their boundary. There may now be any amount of internal electric energy, existing independently of the external, depending upon the internal capacity of the conductor, in which there is electric force, and consequently elastic displacement if there be capacity for it.

(*bb*). If, in the final state (*b*), we unite P to Q by a second dielectric wire also of infinite capacity, we make a closed dielectric circuit which has no elastance (or elastic resistance to displacement), and in which infinite displacement corresponds to finite impressed force, and likewise infinite electric energy. Clearly this is an impossible example, and we should never reach the final state. Let us therefore modify the conditions somewhat. Do away with the impressed force *e* at *x*, and substitute a bodily distribution of impressed force similar to that of the polar electric force (reversed) in the conductor in example (*aa*). Or, substitute equivalent intrinsic electrisation. Or, finally, a distribution of magnetic current on the boundary given by $g = VFN/4\pi$, if F is the external electric force in example (*aa*), and N a unit vector normal from the solid to the air. This magnetic current goes round the wire at *x* in the same direction as in (*b*), and oppositely round all the rest of the circuit. It is strong at *x* and weak

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elsewhere, of such strength that total at x equals that elsewhere.

With this changed distribution of impressed force or equivalents, the external electric field will be identically that in (*cc*). The impossible infinite internal displacement is abolished, the total impressed force round the circuit (of the solid dielectric) is zero; there is a finite internal displacement which exactly closes the external; and there is no internal energy, because there is no electric force. (That is to say, as c is increased the internal energy becomes less and less without limit, the electric force going down to zero, the displacement assuming a finite value.)

(*aa*). If in the final state (*a*) we unite P to Q by a second iron wire, also of infinite permeability, we make a circuit of infinite permeance in which is a finite impressed force, so that we have infinite internal induction and magnetic energy to correspond. Modify as in (*bb*). Do away with the impressed magnetic force h at x, and substitute a bodily distribution of impressed magnetic force (or intrinsic magnetisation) similar to that of impressed electric force in (*bb*) or of the polar auxiliary force (reversed) in (*cc*). Or, substitute a distribution of electric current on the boundary given by $\gamma = VNH/4\pi$, if H is the external magnetic force, when similarly distributed to the external electric force in (*aa*) and (*bb*). This boundary false electric current is similarly arranged to that of magnetic current in (*bb*), except in reversal of direction of circulation everywhere.

Under the changed circumstances, there will be no internal magnetic force, and no magnetic energy, but finite magnetic induction, which will exactly close the external induction, which, again, has the same distribution as the displacement in the air in cases (*cc*) and (*bb*).

(*dd*). We should cause the same external induction, as just arrived at, without modifying the distribution of impressed force, if we could impart magnetic conductivity to the iron circuit. That is to say, in example (*d*) unite P to Q by a second magnetically conductive iron wire. If the distribution of magnetic conductivity be the same as that of electric conductivity in (*cc*), we shall have the external magnetic induction distributed like the electric induction in (*cc*) and (*bb*), and like the magnetic induction in (*aa*). There would be a steady conduction magnetic current in the iron circuit, similar to that of electric current in (*cc*), and the internal magnetic energy (like the internal electric energy in (*cc*)) would be arbitrary, depending upon the permeability of the iron. (In this replacement of electric conduction current by magnetic conduction current, the electric conductivity of the iron circuit is ignored. Similarly in (*ddd*), later).

Any magnetic field is accompanied either by true electric current Γ or by impressed magnetic force h. For the latter we may substitute a distribution of false electric current γ, such that if it were real the induction would be the same. Similarly, in a non-conducting dielectric in which there is no electrification, the elastic displacement is accompanied either by a true magnetic current $G = \dot{B}/4\pi$, if B is the induction, or by impressed electric force e (or equivalent electrisation). For the latter we may substitute a false magnetic current g. Also, U being the whole electric and T the whole magnetic energy, we have

$$4\pi\gamma = \text{curl}.h;\ 4\pi g = -\text{curl}.e;\ T = \tfrac{1}{2}\Sigma A(\Gamma+\gamma);\ U = \tfrac{1}{2}\Sigma Z(G+g).$$

Here A and Z are the electric and the magnetic impulses that would arise on the sudden removal of h and of e respectively (also partly due to Γ or to G), when the induction or the displacement would wholly subside and spread.

Now, if we confine ourselves to a limited region, we shall still have the electric energy within it expressed in the same manner, provided we include in the false magnetic current g a boundary magnetic current given by $g = VFN/4\pi$, if F be the electric force (not counting impressed e) and N a unit normal from the boundary to the region; and further, provided it be possible to close the displacement outside the region, thus not interfering with that within it. This is not always possible. And the magnetic energy is expressible in the same manner, if we include in γ a boundary false electric current given by $\gamma = VNH/4\pi$, if H is the magnetic force, not counting impressed h; with no reservation as to the possibility of closing the induction outside the region, because it is always possible.

But in neither case is it generally true that these distributions of current (including those on the boundary), would, if they existed alone, set up the identical displacement in the one case and induction in the other, independent of what may be beyond the region. (To illustrate this we need merely take a piece of a round tube of induction, with plane ends cutting the tube perpendicularly. If the induction is uniform and steady, the only electric current is the false current round the round part of the tube, and this solenoid will clearly not produce uniform induction, but induction that spreads out in passing from the middle to either end of the tube.) But we may very easily produce independence of the external state, by short-circuiting the unclosed displacement or induction, as the case may be, by making either the electric capacity or the permeability infinitely great beyond the region. Or, merely by making c or μ infinite in a mere boundary skin, or over enough of it to completely close the displacement or the induction. When this is done, the currents, magnetic or electric as the case may be, produce the exact given displacement or induction within the region, without external aid.

In examples (*b*) and (*c*) we have identical displacement outside the solid dielectric or the conductor. Since the states are steady, $G = 0$. And, as there is no impressed force in the air, which is our region of electric energy, g is reduced to the surface current $g = VFN/4\pi$. This is zero except round x (because F is normal elsewhere), and there it is $g = VNe/4\pi$, which is the value of g in the expression $U = \frac{1}{2}\Sigma Zg$ for the electric energy in the air.

In examples (*a*) and (*d*) the total magnetic energy in the air in the identical distributions of induction is $T = \frac{1}{2}\Sigma A\gamma$, since there is no true electric current. And the false electric current (or it might be a true current in a thin coil) is confined to round x, being given by $\gamma = Vh N/4\pi$.

But in example (*cc*), with electric current in the wire, and in (*bb*) as modified, the magnetic current is no longer confined to be round x, but extends over the whole conductor in (*cc*), and solid dielectric in (*bb*); being $g = VFN/4\pi$, wherein F is no longer normal to most of the surface. This g, used in $U = \frac{1}{2}\Sigma Zg$, gives us the electric energy in the air in both cases. But there is a perfectly arbitrary amount in the conductor in example (*cc*), and none in example (*bb*). In order, therefore, that in (*cc*) the magnetic current should exactly correspond to the external displacement, we must, as before explained, short circuit the latter beyond the air; *i.e.*, make $c = \infty$ outside the air region. We then get the case (*bb*) as modified, and see the reason of the modification.

Similarly, in examples (*aa*) and (*dd*) the energy of the identical external magnetic inductions is $T = \frac{1}{2}\Sigma A\gamma$, wherein γ is the boundary electric current given by $\gamma = VNH/4\pi$. But in (*dd*) there is also an arbitrary amount of internal magnetic energy, so that the boundary current γ would not generally, existing alone, produce the actual external magnetic induction It can be made to do so by abolishing the impressed force h at x in (*dd*) and making $\mu = \infty$ throughout the iron. Then we obtain (*aa*) as modified.

(*ccc*). In example (*cc*), with dissipation of energy by conduction, there is also magnetic energy, not before mentioned, as it would have introduced some confusion. For all space its amount is $T = \frac{1}{2}\Sigma AC$, if A is the electric impulse and C the conduction current in the wire. That part of it in the air is $\frac{1}{2}\Sigma A\gamma$ where $\gamma = VNH/4\pi$. This is a boundary current, not round the wire, but along it, of the same total amount as the real current in it, as if it were all pressed to the surface. It would not alone set up the external field, but would do so if we short circuit as much of the induction of the field that is unclosed (at the boundary).

(*ddd*). Similarly, in the unreal example (*dd*) with dissipation by the magnetic conduction current in the iron circuit, there is, besides the magnetic energy, also electric energy. In all space, the amount is $U = \frac{1}{2}\Sigma ZG$, if G be the magnetic current in the wire. That in the air alone amounts to $\frac{1}{2}\Sigma Zg$, where g is a surface magnetic current given by $g = VFN/4\pi$. It is

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along the wire like G inside, of the same total amount, as if G were pressed to the boundary. It would exactly correspond to the external displacement, if the latter were short-circuited at the boundary.

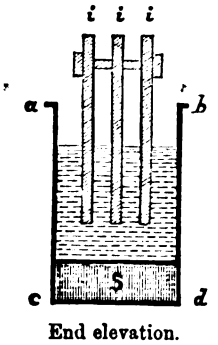
The unreal (*d*), (*dd*), and (*ddd*) are merely brought in because they, to a certain extent, assist the other comparisons.

To be continued.

A MODIFICATION OF DANIELL'S BATTERY, USING IRON AS THE ELECTRO-POSITIVE ELEMENT.

By J. J. Coleman, F.I.C., F.C.S., President of the Chemical Section Glasgow Philosophical Society.

"It seems very singular to me that more attention has not been bestowed upon the utilisation of iron as the substance to be burned in the battery, seeing that the oxidation of iron, according to the researches of Andrews and Favre and Silberman, develops two-thirds or three-fourths as much heat, weight for weight, as zinc. The exact figures are these—677 as against 847, supposing the iron is used to precipitate copper sulphate solution instead of zinc. Iron has been frequently used as the electro-negative element of a battery, especially when in the passive state by contact with concentrated nitric acid. Probably the objection to its use as an electro-positive element has arisen from the earlier experiments finding local action uncontrollable, which in the case of zinc could be obviated by the expedient of amalgamation. I have recently made some experiments in this direction. In point of fact, I have constructed a sulphate of copper cell in which the copper is used in contsct with sulphate copper, as is customary in Daniell's cell, but the zinc is replaced with iron used in contact with ferrous sulphate. I find that three of such cells connected in series decompose water, so that the electromotive force is probably what theory indicates, about two-thirds of a Daniell cell. Moreover, such a form of battery gives what the practical chemist dearly loves, viz., a chemical cycle easily worked, and restoring the materials to their original state. The solution of sulphate of iron produced by the working of the battery on evaporation and distillation yields sulphuric acid and peroxide of iron, the former ready to be combined again with the deposited copper, and the latter ready for the blast furnace to be reconverted into metallic iron. For the prevention of local actions, I find that a form of battery similar to the Medinger or Sir William Thomson battery answers, with some important practical alterations of detail, and this battery, requiring no porous cells, can be made of any size desirable.



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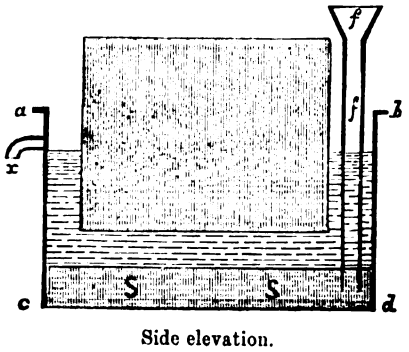

Side elevation.

These words formed a portion of a recent address to the Philosophical Society of Glasgow, but since then I have had occasion to construct a constant battery for working a Ruhmkorff induction coil, employed for a lengthened series of experiments upon ozone during the months of June, July, and August of this year. The battery was constructed of twelve cells, having the following form, and worked remarkably steady for the whole period of three months, as evidenced by the length of the spark of the induction coil, which was sometimes worked for thirty hours consecutively:—*a b c d* is a copper cell, *i i i* are iron plates dipping into solution of ferrous sulphate dissolved in four parts of water. *s s s* is a layer of saturated solution of copper sulphate introduced by the funnel *f f f*, having a wide stem so as to prevent hydrostatic pressure causing current in the ferrous solution.

When the cell was thus prepared it was found that the layer of sulphate of copper solution remained without any appreciable diffusion into the sulphate of iron solution for two months.

After the iron plates *i i i* were placed in position, and the 12 cells were connected in series, the surface of the iron solution was protected from the oxidising influence of the atmosphere by a layer of oil, and the whole was allowed to remain at rest, with the exception that as the sulphate of copper became exhausted a little fresh saturated solution of sulphate copper* was poured down the funnel *f*, and a corresponding quantity of sulphate of iron solution was drawn off at the point *x*. It was found that cast-iron plates were very unevenly acted upon; they became friable and spongy, and resembled in appearance cast iron which has been immersed for a number of years in sea water. Mallable iron plates were more satisfactory, and were easily cleaned, after being in use for a period of three months.

Mr. Bottomley has been kind enough to test one of the cells in Sir W. Thomson's laboratory, and has found the E.M.F. to be ·53 of a Daniell cell. Possibly better results may be obtained, and for this reason a few more tests will be made with a few cells connected in series. Meantime it has been noted that with about 100 square inches of surface of the copper plate, the *electrolytic* deposition of copper in each cell amounts to about 1oz. avoidupois in 24 hours, the electrodes being connected with thick wire.

Although the E.M.F. of this battery is small, the cheapness of the materials and the facility with which they may be obtained and restored to their pristine state in unlimited quantity makes it worthy of some notice. There is no doubt that any method of constructing a primary battery which involves selling of a product likely to glut the markets is of little national importance, but any effort to utilise a material like iron, even although the action may be slow, or the apparatus cumbersome, is worthy of attention. Moreover, the recovery of the sulphuric acid by the simple process of distillation from sulphide of iron has been practised a long time in Germany, the product being called nordhausen sulphuric acid, and the manipulation of copper solutions with iron is already carried out on an enormous scale in this country at the works of Tharsis and other copper works.

THE ELECTRO-OPTIC ACTION OF A CHARGED FRANKLIN'S PLATE.†

BY J. KERR, LL.D.

The experiments described in this paper were carried out by the author in 1882, and he has now made them known in view of certain statements made by M. Wiedemann in his *Die lehre von der Electricität*, Vol. II., particularly where he says that there appears to be no electro-optic double refraction in the case of a uniformly charged Franklin's plate. The results obtained were shown by the author to prove that electrostatically strained glass acts in the polariscope as if compressed along the lines of electric force, *and this always whether the electric field is uniform or not.*

MULTIPLYING POTENTIAL.‡

BY SIR WILLIAM THOMSON, F.R.S.

The method described by the author was to arrange in series a number, *n*, of condensers, where *n* is the number

* Care must be taken that the sulphate copper solution is absolutely saturated with the salt.

† Abstract of a Paper read at the British Association meeting at Aberdeen.

‡ Abstract of a paper, entitled "On a method of Multiplying Potential from a Hundred to Several Thousand Volts," read at the British Association meeting at Aberdeen.

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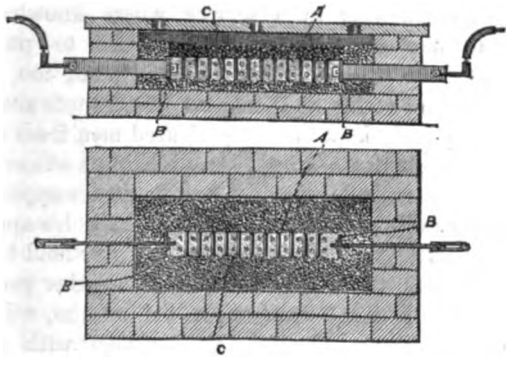
indicating the required multiplication. A terminal is connected to the junction between each pair of adjacent condensers. This series of n and the terminals is conveniently placed, so that by a suitable mechanism a pair of movable electrodes, between which a known difference of potentials exists, may be brought successively into contact with each pair of adjacent terminals in the series, moving always in the same direction along them. In this way the difference of potential established between the two end terminals of the series of condensers is n times the known difference of potentials between the movable electrodes.

AN ELECTRICAL FURNACE FOR REDUCING REFRACTORY ORES.*

BY DR. T. STERRY HUNT.

The application of electricity in the extraction of metals has hitherto been chiefly confined to the electrolysis of dissolved or fused compounds of these by various methods. The power of electric currents to generate intense heat in their passage through a resisting medium has, however, long been known, and the late W. Siemens thereby succeded in fusing considerable quantities of steel. It was, however, reserved to Messrs. Eugene H. and Alfred H. Cowles, of Cleveland, Ohio, to take a new step in the metallurgic art by making the heat thus produced a means of reducing in the presence of carbon the oxides not only of the alkaline metals, but of calcium, magnesium, manganese, aluminium, silicon, and boron, with an ease that permits the production of these elements and their alloys with copper and other metals on a commercial scale.



Electrical Furnace for Reducing Refractory Ores.

In the apparatus devised and now employed by the Messrs. Cowles a column of fragments of well-calcined charcoal, so prepared and arranged as to present the requisite electrical resistance, is embedded horizontally in finely-pulverised charcoal, and covered by a layer of the same material coarsely broken, the whole being arranged in a box of fire-brick, covered with perforated tiles and opened at the ends to admit two carbon electrodes an inch and a half in diameter. Through these the current from a dynamo-electric machine of 30 horse-power is now made to traverse the central core of carbon, whereby such a temperature is at once produced therein that platin-iridium may be instantly melted, and the most refractory oxides already named may be not only fused and volatilised, but reduced to their elemental state with formation of carbonic oxide gas.

If alumina in the form of granulated corundum is mingled with the carbon in the electric path, aluminium is rapidly liberated, being in part carried off with the escaping gas, and in part condensed in the upper layer of charcoal. In this way are obtained considerable masses of nearly pure fused aluminium and others of a crystalline compound of the metal with carbon. When, however, a portion of granulated copper is placed with the corundum, an alloy of the two metals is obtained, which is probably formed in the overlying stratum, but at the close of the operation is found in fused masses below. In this way there is got, after the current has passed for an hour and a half through the furnace, from four to five pounds of an alloy containing from 15 to 20 per cent. of aluminium, and free from iron. On substituting this alloy for copper in a second operation, a compound with over 30 per cent. is obtained. Already the small experimental plant with a 30 horse-power dynamo is producing daily over five pounds of aluminium in the form of a rich and brittle alloy, which by suitable additions of copper is converted into different grades of aluminium bronze. The valuable qualities of these are so well known that it is only their great cost hitherto that has prevented their more general use in the arts. They are now offered for sale at Cleveland on a basis of five dollars a pound for the contained aluminium. The reduction of silicon is even more easy than that of aluminium. When siliceous sand, mixed with carbon, is placed in the path of the electric current, a part of it is fused into a clear glass, and a part reduced, with the production of considerable masses of crystallised silicon, a portion of this being volatilised and reconverted into silica. By the addition of granulated copper there is readily formed a hard, brittle alloy, holding six or seven per cent of silicon, from which silicon bronzes can be cheaply made. The direct reduction of clay gives an alloy of silicon and aluminium, and with copper a silico-aluminium bronze that appears to possess properties not less valuable than the compound already mentioned. Even boric oxide is rapidly reduced with evolutions of copious brown fumes, and the formation in presence of copper of a boron bronze that promises to be of value, while under certain conditions crystals of what appears to be the so-called adamantoid boron are formed. In some cases, also, crystalline graphite has been produced, apparently through the solvent action of aluminium upon carbon.

Remarkable results are got by alloying small quantities of aluminium with an admixture of copper and nickel. One of these compounds broke with a strain of 111,000 pounds to the square inch, with an elongation of 35 hundredths, while a 10 per cent. aluminium bronze broke with 109,000 pounds. An addition of from 2 to 3 per cent. of aluminium to brass greatly increases its tensile strength, and renders it less susceptible to oxidation. While 15 or 20 per cent. of aluminium with copper yields a brittle compound, an addition of 10 per cent. gives to pure aluminium a great increase of hardness and tenacity, forming an alloy that may have a wide application. It may be added that the difficulties in the way of getting together the reduced aluminium without the aid of copper promise to be overcome at an early day, so that we may expect the cheap production of such alloys and of pure aluminium.

The Messrs. Cowles, in their later work, have been aided by the chemical skill of Prof. C. F. Mabery, now of Cleveland, who is associated with them in some of their patents. These now cover not only the reduction of aluminium, silicon, and boron, as described, but the extraction of manganese, magnesium, and the alkaline metals by the electric furnace. I had the pleasure of hearing Prof. Mabery give the first scientific notice of this discovery before the American Association for the advancement of Science, at Ann Arbor, August 28th, and then spoke of the early results of Deville, and those of Debray, on aluminium and its alloys, having myself witnessed many of the experiments of both of these chemists thereon. I also insisted that the importance of this new instrument that the Messrs. Cowles have placed in the hands of chemists for producing and controlling degrees of temperature never before obtained can scarcely yet be estimated, either in its economic or its scientific aspect. This heat of the furnace realises the dream of the alkahest or universal solvent of the alchemists, and he who can rightly use it will be worthy of the ancient title of "magister magnis in ignis."

I then suggested trials for the reduction of titanium, both from rutile and from titanic iron ore, which will probably soon be made.

I may add that, through the courtesy of these gentlemen, I have since been enabled to spend two entire days in their experimental works at Cleveland, with the brothers Cowles and Professor Mabery, when they explained to me several points not yet made public, and allowed me to direct experiments with one of their furnaces. The fusion of quartz and the reduction of silicon without the presence of copper was repeated, the reduction of boron and the formation of boron bronze, with many other interesting experiments.

The present plant at Cleveland is but a first experimental one, and has only been in operation a few months. The Cowles Electric Smelting Company has secured a large water-power at Lockport, New York, and a dynamo electric machine of 125 horse-power is now building for them at the Brush Works in Cleveland, which will soon be in operation at Lockport, and will permit of the establishment of the electric furnace on a larger scale.

A series of experiments of the products got by this remarkable discovery is, by the courtesy of these gentlemen, placed before the members of the Institute.

* A paper read before the American Institute of Mining Engineers at Halifax.

PRIMERS OF ELECTRICITY.—These Primers (by Prof. Houston and others), which had a large sale at the Philadelphia Exhibition, and of which the second edition has recently been printed, can be obtained at the office of *The Electrician*, price 1s. the set of twenty-nine, post free 1s. 2d.; bound in boards, 1s. 6d., post free 1s. 9d.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE INDIAN TELEGRAPH SERVICE.

Although the officers of the Indian Government Telegraphs are greatly to be commiserated in respect to the block of promotion which has existed in that service for many years past, they may count themselves extremely fortunate in the interest they have aroused by laying their grievances before the English public. The letters and articles on the subject which have recently appeared in the home press show that the welfare of our countrymen and fellow workers in India is not a matter of indifference to us; but they also show that the parties most nearly concerned have a shrewd practical knowledge of the ways of English journalism. However warm may be our sympathy, we cannot write sympathetically without some knowledge of the facts; and these the wideawake Telegraph Engineers of India have taken care to supply with a free hand. The documentary evidence, bearing date Simla, 15th August, 1885, and printed apparently by the aggrieved officials, supplies all the details that were wanting in the preliminary letters and articles which appeared some little time back, one of which we reprinted in *The Electrician* of 28th August. Judging by precedent and experience, we should confidently say that the memorialists will succeed in their efforts. They certainly deserve to succeed, for they have not only a good case, but one which they have had the courage and sense to put forward in a way that renders failure almost impossible. Heads of Departments often incur the reproach of yielding to clamour; but clamour is none the less necessary at times to give a plausible excuse for yielding to claims which, though undeniably just, are not self-evident. The case of the Indian Telegraph Service can no longer be hushed up by the Government of India; and a thorough investigation, the materials for which are now in the hands of the English public, must certainly result in some substantial redress.

Into all the particulars of this strange business we need not enter at length. The latest memorandum of the Director-General of Indian Telegraphs dealing with the subject is sufficient of itself both to establish the case of the complainants and to condemn the proposed remedy. This memorandum, dated 16th July of the present year, admits the fact that most of the surviving officers of the seventy-two who were added to the Superior Establishment as long ago as 1868-72 are debarred by the organisation of that establishment from receiving promotion; but the only relief it suggests to improve their prospects and those of their juniors on the list, who are of course similarly blocked, is the offer of a transfer to another branch of the Indian Civil Service—the Accounts Branch of the Public Works Department. From an administrative point of view such a proposition seems almost incredible. What are we to think of a department which coolly proposes to deprive itself of a number of experienced technical and scientific officers, of fifteen years' standing in a service where knowledge and experience count for everything, in order to push their juniors into the vacant places? And what, too, of that other department of Public Works whose accounts are capable of being adequately kept by inexperienced men fresh from the field of Telegraph Engineering? Any telegraph officer desirous of being so transferred is invited to submit his application at once; the meaning of which is plainly, that if his application is not made forthwith the officer must for ever hold his peace. We suspect that the Director-General, or rather perhaps we should say the Indian Government behind him, will be mistaken in both these calculations. No man with any self-respect would voluntarily quit a department in which he has spent the best of his days to become an interloper in another of which he knows nothing, unless his transfer is accompanied by substantial advantage such as would convert an otherwise ignominious shunt into an honourable distinction. The proposition in question effectually bars any move of the kind, by declaring that, as to the terms of transfer, "all that can be said at present is that no officer will receive in his new position less pay than he draws at present." As there is no trace of conscious humour about the wording of this grotesque deliverance we can only suppose that it was deliberately framed as an affront and a snub.

Of course the official mind, which is always ready to seize the weak points in a memorial, will find some in this. It will notice that the memorialists have occasionally overdrawn their case, more in the spirit of the special pleader than of "gentlemen by education and feeling." Also that, in spite of disclaimers to the contrary, there is some unseemly asperity displayed towards the old establishment officers, who, though not less deserving than themselves, have been more fortunate, and who on this account are flippantly spoken of as "the men who create the block." Lastly, the remedy proposed by the memorialists themselves is open to the remark that it amounts precisely to the same thing as that suggested by the Government, only the "men" are different. If it be right to pension off a number of old servants to make room for younger ones, it cannot be wrong to transfer these younger

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ones to make places for others that are younger still. This is an obvious departmental retort, and the officers now suffering from ten years' stagnation in promotion would have been better advised to have shown more consideration not only for the interests of the service, but the feelings of the men of the older establishment. If these latter are willing to quit the service, and if they can be dispensed with without detriment to it, then the case is different; but it ought to have been set forth in the memorial. For our own part we do not like the idea of enforced pensioning, except where there is proved incompetency; and as a mode of clearing the way for fresh promotions it involves an obvious waste of money. A lesser extravagance, it seems to us, would be to repeat, so far as may be needful, the step taken in 1867, namely, enlarging the establishment, but without repeating the blunder of that year—the importation of a redundant force from England. By all accounts the duties of the superior officers are very heavy and responsible. To lighten them and increase the emoluments would be a more rational course than to disburse large sums for pensions of an absolutely unremunerative character. As appointments fell in, either by casualty or superannuation, the duties could be apportioned among the existing staff, and the redundancy would be gradually got rid of.

We speak with diffidence, however, of a service with which we are necessarily in comparative ignorance; and practical remedies probably can be framed only on the spot. But we are clear as to the justice of the case put forward by the memorialists; and our sole misgiving is lest there should be any lack of justice on their parts towards their employers or their fellow officers. As regards the Indian Government, its duty in this matter is plain; the misrepresentations of 1866 must be atoned for, and the error in calculation which introduced to the service a great number of highly qualified persons, with great expectations impossible of realisation, must not be laid on them. We do not blame the Government for having filled the newly authorised appointments with men of the old establishment; it would have been absurd to put the new men over their heads. But the consequent deadlock is entirely the fault of the Indian authorities; and as it has resulted in a grievous wrong to the parties who were unwittingly deceived by them, this wrong should be promptly and cheerfully rectified, cost what it may.

CORRESPONDENCE.

A PHENOMENON OF CURRENT INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The effect noticed by Mr. Williams, p. 395, is one familiar, no doubt, to all who have worked with several induction coils. I have frequently seen the vibration of the spring entirely stopped on the closing of the secondary circuit. This happens with medical coils, with a separate horse-shoe magnet for the break, when the spring is weak. If the two handles are brought into contact, the magnetism overpowers the spring, and sets up a residual effect, which holds the armature down, and breaks circuit altogether.

The stored energy of the magnetised core escapes at the moment of break, either as heat in the core or as electric current in the primary and secondary wires, dividing between these two in ratios governed by the construction and conditions. The variation of these ratios amounting to the resistance of the secondary circuit is manifested both by the rate of vibration of the spring and by the brightness of the spark at the break. These currents, being in the same direction as the primary current, reduce the speed of demagnetisation—that is to say, they represent the magnetising effect which equal currents would have if sent into the two circuits from an external source. This effect, of course, varies with the conditions existing in the two circuits, *i.e.*, the ampere-turn values modified by their distance from the core. Their effect is to retard the recoil of the armature and lengthen the period of the breach of circuit of the primary source. Therefore any variation in these currents results in a variation of the rate of vibration of the spring.—Yours, &c.,

JOHN T. SPRAGUE.

THE TELEPHONE IN CINTRA (PORTUGAL).

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the issue of *The Electrician* for June 26 last, Mr. Danvers has made rather a mistake in trying to claim the novel use of rockets in passing telephone wire as his own idea. Perhaps Mr. Danvers will remember my using the bow and arrow, slug sling, &c., in passing wires over the many forbidden houses, convents, vineyards, olive tree plantations, &c., in and out of Lisbon, as rockets were then too expensive an item.

By inserting the above you will greatly oblige, yours, &c.,

ALFRED J. THOMPSON, Electrician, China and Japan Telephone Company, Shanghai, China.

ON A NEW FORM OF GALVANOMETER.*

BY PROF. JAMES BLYTH, M.A., F.R.S.E.

The object of this short communication is to describe a method of measuring electric currents by means of an instrument whose scale is graduated to equal divisions, and whose deflections are, from the intrinsic nature of the instrument, proportional to the current strength through all ranges.

In principle the instrument depends upon the mechanical action exerted by a magnetic field upon a movable conductor carrying a current. In construction it is essentially similar to the well-known apparatus, due to Faraday, for showing the continuous rotation across the lines of magnetic force of a horizontal radial conductor carrying a current and having slipping contacts at its centre and circumference. The construction will be understood from the following description:—

Two bundles of permanently magnetised steel wires are made up in the form of cylinders having narrow axial holes. These are fixed with their axes in the same vertical line, separated by a narrow gap, and so that the north poles of the one set of magnets face the south poles of the other. In this gap the magnetic field is sensibly uniform and the lines of force vertical. Inserted in the gap is a thin circular disc of wood or vulcanite, having a central mercury cup and a concentric circular mercury trough at a short distance from it. A stout brass rod is provided, having a short thick copper wire rigidly attached at right angles to its lower end. Its upper end passes freely through the axial hole in the upper magnet, and is rigidly attached to the lower end of a long fine torsion wire of steel or silver, whose upper end is fixed to a suitable support. The lower end of the brass rod dips into the central mercury cup, and the outer end of the copper wire (bent down a little at right angles) dips into the concentric canal of mercury. Stout copper wires are led from the central cup and canal to binding screws suitably placed so as to form the terminals of the instrument. The upper end of the brass rod, which projects a little above the upper magnet, carries a long pointer, which moves over a horizontal circular disc, graduated either to degrees or to show amperes directly. This disc is fixed with the torsion wire passing freely through its centre. The whole is so enclosed as to be free from air current.

The action of the instrument will be easily understood. Suppose a current sent through it. As is well known, the electromagnetic force acting on the radial current will tend to make it rotate in a horizontal plane with a uniform force. This rotation will go on till a certain angle is reached, when

* Paper read before the British Association at the Aberdeen meeting, September, 1885.

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the moment due to the electromagnetic force is balanced by the moment due to the torsion of the wire.

Let i = the current strength,
a = the length of the radial wire,
N = the magnetic induction,
A = the torsion constant,
θ = the angle of equilibrium,

we have $\frac{1}{2} ia^2 \mathrm{N} = \mathrm{A}\theta$; or $i = \frac{2\,\mathrm{A}}{a^2 \mathrm{N}}\,\theta$,

showing that the current strength is proportional to the angle of deflection.

The instrument admits of several modifications. I have constructed two in addition to the above. In the one the permanent magnets are replaced by similarly-placed electromagnetic coils, through which the current to be measured passes. In this case the square of the current strength is proportional to the angle of deflection. In the other the fixed magnets are dispensed with, and instead a cylindrical bundle of magnets is fixed coaxially to the brass rod, but insulated from it, so that it rotates along with the rod and radial wire. In this case the radial wire projects from the middle of the length of the magnet bundle, while the lower end of the brass rod is prolonged so as to dip into a mercury cup at a considerable distance below the lower end of the bundle. Owing to the influence of the exterior part of the circuit leading from the mercury canal to the cup, the equation for this case is a little more complicated. With proper arrangements, however, the deflection can be shown to be proportional to the current strength.

In the instruments constructed for practical use the mercury cup and canal are so made, on the unspillable ink-bottle principle, as to preserve the mercury in case of being knocked over or even inverted.

MESSRS. PAXMAN AT THE INVENTORIES.

On Saturday evening last, at the invitation of Messrs. Paxman and Balls (Messrs. Paxman and Co.), a party of scientific gentlemen was entertained at dinner at the Inventions Exhibition to welcome Sir Philip Cunliffe Owen upon his return to what may be termed active duties, after a long and serious illness.

The occasion of the dinner was an acknowledgement of the very remarkable success achieved by Messrs. Paxman and Co. with the steam engines of their construction by which the machinery for lighting the Exhibition by electricity has been driven. The popularity and success of the Exhibition has been largely due to the very extensive adoption of the electric light, and, indeed, without this splendid light much of the attractiveness of the Exhibition would have been entirely wanting, and many of the chief features could not have been carried out.

The success of the electric light at the Inventions is of far greater importance than at first sight appears. Three millions of the public, more or less, have thus seen that the *fiasco* of electric lighting companies' bubbles was not through the failure of the light, but through the impotence of those who undertook to develop it. There is now no doubt as to its flexibility, for here it is seen adapted to interiors, exteriors, and fairy land effects. One of the most important features in any electric light system is the motor driving the dynamos. The latter may to a certain extent regulate, but failure of the motor cannot be compensated by any regulation of the dynamos. It must not be forgotten that originally Messrs. Davey, Paxman and Co. undertook to provide motor power at a very short notice, and a due meed of praise should be awarded, not only for their success at the Inventions, but for their success from the commencement of their work. The Executive have had a wonderful chance in their hands, but so far have failed to take advantage of it. An almost perfect monograph could have been obtained on electric lighting by this time. Suppose that it had cost the Executive £10,000, what of that? The public pay, and gladly pay. In our estimation not a revolution of an engine or a dynamo should take place without a record. Coal should be weighed, water measured, dynamometers and photometers everywhere. The electric light, in fact, should here be one gigantic scientific experiment, and the results rigidly obtained and verified.

Engines for electric lighting purposes must be capable of working with almost absolute uniformity of speed for a great length of time, and must be thoroughly trustworthy as not liable to failure in any sense, even for a few minutes. All the larger engines in the electric lighting department are by Messrs. Paxman and Co., and the perfection of their work has shown itself in remarkable contrast with a number of small high speed engines which were admitted into this department for driving some machines direct. Altogether Messrs. Paxman and Co. have provided about 1,200 horse-power in the electric lighting department, and they have also provided steam by means of a number of very fine locomotive boilers supplied from their works, which are capable of giving off 1,300 horse-power, thus making a total of 2,500 horse-power. These boilers have been called upon to perform much heavier work than was intended, in consequence of the heavy consumption of steam by some of the small high-speed engines, and through the failure of some of these much extra work has been imposed upon the large engines of the Colchester firm. The high excellence of the design and workmanship, and the economy of fuel consumption by these engines has, however, enabled them to perform this work without any difficulty. They are all fitted with Paxman's well-known automatic expansion gear and governors, and several of them are on the compound system, by which great economy of fuel and steadiness of running are ensured.

The unqualified success of the Colchester engines in different parts of the world has been fully confirmed by a most severe test in the recent Fisheries and Health Exhibitions, and also in the Inventories, and the executive committee have warmly acknowledged their indebtedness to Messrs. Paxman and Co., who are to be congratulated on a success which can only be attained by the best designs, materials, and workmanship, combined with a thorough knowledge of what is required. It may also be mentioned that this firm have not only received a gold medal at this Exhibition, but also at the two previous ones.

But to return to our immediate subject. A hearty welcome was given to Sir Philip Cunliffe Owen, who, in replying to the toast, stated that the preliminary work in connection with next year's Exhibition was well advanced, and that the space was fully occupied.—Sir F. Bramwell replied on behalf of the executive committee, and Sir F. Abel on behalf of the lighting committee, and both spoke in high terms of the manner in which the firm of Messrs. Paxman and Co. had fulfilled all demands made upon them.

THE DISTRIBUTION OF ELECTRICITY.*

BY PROF. GEORGE FORBES.

LECTURE I.—INTRODUCTORY.

When asked to give a course of lectures on the distribution of electricity, I was very pleased to accept the task, because I felt that such a work was much needed. Numbers of engineers have worked out very fully numerous problems in electrical distribution for their own wants, but no classification of systems has been attempted, and no work has been published to assist the engineer in drawing out specifications and selecting between systems.

I also felt that a principal reason why public electric lighting had made so small progress was the difficulty of planning a system of distribution, and the probability that an expensive system proposed to-day would be superseded by a more economical system next year.

The low pressure system, called multiple arc distribution, is enormously expensive, and necessitates the engine house being in the centre of the populous district lighted, and this is seldom feasible. A high pressure system gets over this difficulty, but we can hardly say that any such system has yet been brought to practical perfection. This is what is wanted for large central station lighting, although much can be done even on the expensive low pressure plan.

At first I proposed to make these lectures extremely popular. But as I progressed I found that I should sacrifice too much by avoiding technicalities, and I felt that the time I have spent on their preparation would have better fruit if I addressed myself more directly to brother engineers, but still in language clear enough to be understood by a non-technical audience.

I shall use the parliamentary term "pressure" in these lectures, signifying difference of electric potential between the two conductors. Those who have had most to do with large practical installations know best what serious items are the cost of conductors and the purchase of a site. The latter would be enormously diminished if the works could be at a distance. It is my duty in these lectures to see how far in each system of distribution the cost of conductors can be diminished; and wherever economy clashes with other facts, and introduces new engineering difficulties, it will be my duty to show how these engineering difficulties may be removed.

One thing I must insist upon. If the economical considerations lead us to a large conductor, we must recommend that large conductor. No financial questions of a difficulty in raising the money may be allowed to influence the engineer in recommending a smaller conductor than his calculations have proved to be the most ecomical in the end.

You all know the different systems which have been proposed for lighting. You know how arc lights have been distributed in series, and how incandescent lamps have been put on multiple arc in large stations.

* The Cantor Lecture of Professor George Forbes, delivered on February 2nd, 1885. From the *Journal of the Society of Arts*.

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More especially you are acquainted with what has been done in America in this matter. In some cases only has a special system been thoroughly worked out; and in very few cases, I fancy, have different systems been relatively compared and pursued so as to bring out the most economical conditions possible.

Besides these different systems I have spoken of—the series and multiple arc systems—you are aware that the latter, the multiple arc, is divided into a number of different modes of distribution. You have all heard people talking about the network system, the system with three mains, and also of lines-of-centres distribution. These are different modes of multiple arc system. And so also we have another one, which is called the multiple series system, which has been used to a certain extent, and very successfully used, but which has very radical defects in it which have prevented its general adoption; at the same time, many distinguished engineers believe that, in the future, there may be a possibility of making this system efficacious, and of removing the defects which are in the way. The objection to the ordinary multiple system, where all the lamps are connected to two massive mains, or to a number of wires which are so connected together as to make two massive mains, is the enormous cost of the conductors.

Besides the difficulty that the Electric Lighting Act is unworkable, as every unprejudiced person must admit that it is, there is no doubt another fact which has largely hindered electric lighting, and that is the enormous cost of the mains. And not only that, but the multiple arc system introduces another serious expense. It becomes essential with such large mains to have our central station and our engines in the centre of the district which is being supplied. Now, in a thickly populated neighbourhood, such as it would be economical to light on the multiple arc system, it is very difficult to get a site for your engine and dynamos, and this has been acknowledged by those who have tried to undertake the system in London to be one of the most serious objections to the multiple arc system. Thus at every point we see that it is of the utmost importance that engineers should devote their attention to economy in the construction of their mains, to enable us to have a good supply after the most economical system of mains which is possible, whether that system be multiple arc or multiple series, or any other of the modifications which have been proposed. It is at present the earnest hope of thousands and thousands of the inhabitants of our great towns that they may have electricity supplied to their houses from central stations, just as gas is at the present time. They have been prevented hitherto from obtaining such a supply, partly by the cost of production and supply, and partly by the jealousies of municipal authorities acting through Parliament, and who have undertaken gas speculations. The public who want the electric supply will not endure this much longer, and it becomes a matter of importance for electricians to see how far they are able to reduce the cost of production and supply.

Production.—The question of production is one which has been very fully discussed. The dynamo machine affords the most economical means of production, and will probably continue to do so. If ever it be superseded, it can only be by a step in our knowledge entitled to the name of a great scientific discovery. Such discoveries do not come at our bidding. They are evolved in the laboratory of the patient scientific inquirer, and seldom in the workshop of the speculative inventor. In selecting our dynamo, cost of manufacture and maintenance, and cost of production of electrical energy, are the chief items to be considered. For a central station with 10,000 lamps we want to have about 1,000 electrical horse-power in the circuit. We may use high-tension machines in parallel, or low-tension machines in series, until we get in the external circuit 7,500 amperes and 100 volts (if such be the class of lamp we are using), or we may use a single machine to produce the same effect. It is better to use a large number of machines, so that they may be each removable and able to be replaced by another when repairs are necessary. But it is a matter of indifference what class of machine we employ (high tension in parallel, or low tension in series), except so far as cost is concerned. We have simply to choose the machine which gives the greatest output of energy in the circuit at the least expense.

I have drawn attention to this because it is important, and because few people have thought of combining low tension machines in series. And I have confidence that the simplicity of construction of these machines, their cheapness and economy of maintenance, and their infinitesimal internal resistance, will lead them to be generally adopted.

The question of primary batteries must be laid on one side as being quite too costly. If a battery were made practical in which coke or charcoal should be consumed instead of zinc, we might discuss the matter. In 1880, I made a number of partially successful experiments in this line, but with no very definite result. If, on the other hand, the residual products of a battery were valuable, and there was unlimited demand for them, some progress might be made. And yet we have no reason for hope in this direction. Secondary batteries being dependent entirely upon the dynamo, are connected with the supply rather than with the production of the current.

There are other systems, such as that which utilises alteranate currents combined with the induced current distributors on the plan perfected by Messrs. Gaulard and Gibbs. This also is rather a question of supply and distribution, and will be left to a later stage for discussion.

Leaving now the question of the production of electricity on one side, the next point to be considered is its distribution and supply. But before attacking this problem directly, I should like to make a comparison of it with the similar problem with respect to gas.

Comparison with Gas Distribution.—The production of gas is a somewhat extensive laboratory experiment enlarged to a commercial scale. The distillation of coal, and the subsequent treatment of the gas by condensers, scrubbers, and lime purifiers, previous to its admission through the regulator and station meter to the gas holder, is really a complicated process compared with the production of electricity. In its distribution through mains to the houses of individuals, the problem is very similar to the problem for electricity. A certain pressure is given to the gas at the central station. With this pressure it must be forced through the mains, and must be delivered to the gas jets of consumers at a definite pressure. The pressure must not vary seriously with the number of jets in use, nor with the position of a house in the district. There must be no leakage in the pipes, or as little as possible. In all these points electricity has its analogue. Moreover, a difference of pressure will establish itself if the flow of gas and the resistance of the pipes to this flow are large; and the larger the pipes the less is this resistance. Hitherto the analogies are very striking. There are, however, two points of difference. First, in gas distribution the resistance to the flow of gas is not proportional inversely to the area of the pipe, so that while with electricity the resistance of 100 parallel wires is the same as that of one wire 100 times the section, this is not the case with gas, where the hundred pipes have much more resistance than the simple pipe of a hundred-fold section. Secondly, the cost of gas mains is not proportional to their sectional area, and still less is it proportional to the current of gas it has to carry. With electricity, on the other hand, the cost of mains always increases at least in proportion to the current. The consequence of these facts is, that the cost of mains is an incomparably more important matter in the case of electricity than in that of gas. This is what renders the distribution of electricity so important and worthy of study by the electrician. Upon the arrangements made under this head depends very largely the question whether or not electricity is as cheap a means of lighting as gas.

While comparing gas and electricity, it is surprising to see how great a difficulty has been met in introducing the latter. When gas was introduced the public had no experience of, nor occasion for confidence in, a general supply, and the laying of pipes was a leap in the dark. There was no knowledge of the size of pipes required, there was little means of even guessing at the probable consumption. At the present time a public supply of light is well understood and appreciated, and we know well what currents our wires will carry. Moreover, from the known gas consumption, we can form a more accurate estimate of the probable demand for electricity. Then, at the same time when gas was introduced, the burners were infamous (merely a hole in the top of a closed tube), and the flame was smoky and sulphurous, consumed the oxygen, poisoned the air, and blackened surrounding objects, while its smell was odious and unwholesome. It was not known how to prevent leaks, and leaks meant explosions. The inexperience of the public was certain to leave cocks turned on—hence explosions again, and deaths from suffocation by gas. Gas gave a naked flame which is a constant source of danger, while to-day the incandescent light cannot set light to anything. Yet, in spite of all these advantages, the difficulty of introducing electricity has been far greater than was that of introducing gas. The electric light must contend against a monopoly. Gas had a fair and open field. Our Legislature has favoured the monopolists; the legislators for gas encouraged its development. Gas met with financial speculators just as electricity has done. The monopolists who have sprung into existence are the one deterrent cause.

Distribution of Electricity.—Passing now to the subject of these lectures, it will be well if we give a general survey to-day of the various points with which we have to deal, and of the different plans of distribution, which must afterwards be considered in detail.

The first thing to be noticed is that, in order to give electricity a fair chance in competing with, or supplementing, the gas supply, the cost of one of its most expensive parts, *i.e.*, the conducting mains, must be reduced as low as possible. Various schemes have been proposed with one advantage or another. Some systems have been devised whose speciality is that they do not allow the potential to vary much. Other systems have specially in view the avoidance of total darkness if an accident should occur at any point. At present it is essential that these considerations should be second to economy. Let us first get the most economical system, and all things else shall be added hereafter. Now, in attempting to reduce the size of our conductors, we meet with three difficulties:—1. With small conductors energy is wasted in heating them, and this may become very considerable. Thus, while capital outlay on copper is saved by small conductors, the annual consumption of coal is increased, and large engines and dynamos are required. 2. With large currents this heat may be sufficient to injure the insulation. It also increases the resistance of the conductors; and if the conductors be underground, the heat may become unpleasant to foot passengers. Clearly, the conductors must be large enough to prevent such troubles. 3. There is a loss of potential in the mains, which is greater where these are smaller. This loss is also greater in proportion to the number of lamps fed by the main. The fall of potential with one lamp might be one-tenth of a volt, and with 100 lamps it would be 10 volts. So large a variation under varying conditions of consumption cannot be permitted, and the conductors must be large enough to prevent any such variations.

I propose now to say a few words on each of these heads, in order to prepare the way for criticising different systems of conducting mains.

Now, let us first look at the problem with a few figures before us, to see on what scale we are dealing. Suppose that we are using a conductor of a square inch section to carry 1,000 amperes. The resistance of 100 yards of that conductor of pure copper would be 0·0024 of an ohm. Now, the energy which is used up is given you by the calculation C^2R divided by 746. That is equal to 3·2 horse-power used up in every 100 yards of our conductor for every 1,000 amperes. Now, what is the cost of this electrical horse-power per annum? It is usually considered safe to say a horse-power costs £10 per annum, but, owing to the period in which electricity would be used, this is not a safe figure. Let me begin by considering £20 as the

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cost of horse-power. £64 is the cost of the total horse-power. We have wasted in four years in every 100 yards £256 ; in 20 years £1,280 is wasted in that conductor. Now, if I double the size of my conductor, I have the quantity of power wasting reduced to £640. The question comes to me, would it cost more than £640 of capital to lay down an extra 100 yards of a similar section ? No, it would not ; and, therefore, it is economical to double my conductor. And so we go, step by step, until we find that the gain is just equal to the extra expenditure of capital in the laying down of conductors, and then we have arrived at a satisfactory arrangement. You will easily see if you work this out. Now this is an important point, in fact one of primary importance. It was first approached by Sir William Thomson in an address to the British Associacion, in 1881, in which he read a paper on "The Economy of Metal Conductors of Electricity," and, in that most interesting paper, he arrived at the conclusion that the interest spent upon the capital of the conductors should be equal to the value of the energy which is wasted annually in these conductors.

The first question which becomes a trouble is, what are we to consider the cost of electrical horse-power ? There are two ways of looking at this problem, and we will just glance at them independently. First, let us take the case of an installation which has been carefully estimated for ; and let us see there, after the whole of the buildings, distributing and supply plant, and everything has been laid down, what is the cost of each horse-power of electricity, if you like to call it so. To give you a perfectly unbiased example, I have taken the figures, kindly furnished me by Mr. Crompton, of a large installation for which he carefully prepared estimates. I find, on looking into this, that in this case the cost of electrical horse-power—of course depending on the number of hours used during the year—if it was for 1,000 hours, the cost of horse-power came to about 5d. ; for 2,000 hours in the year, 3·5d. ; and for 3,000 hours only 3d. ; and that means for the year in these three cases it would be 5,000 pence, 7,000 pence, and 9,000 pence. Now, the next question that comes before us is, what is the number of hours we are supposed to use our electricity ? There is very little doubt that about 1,000 hours is probably a fair average consumption for people in a town ; but I think it very likely that, at any rate in the first installation set up, a certain selection will be possible, which will raise the average a little higher. For my own purposes at present, I am going to assume 1,500 hours ; if you prefer another value, you can work it out yourselves to suit it. That will be the average cost of those two, which comes almost exactly to £25 a year. Now, if you work out the cost of the energy wasted in a 1,000 yards conductor, you will find, I think, that the following figures are energy wasted in the conductor for 3½in., 4½in., 4in., 5in., 5½in., 6in., and 6½in. ; the amount is £22·8, £20, £17·8, £16, £14·5, £13·2, and £12. Therefore, the gain in passing from any one to the next is 2·8, 2·2, 1·8, 1·5, 1·3, and 1·2. These are the gains which there are in increasing the size of the conductor.

Up to this point it is all plain sailing, a matter of plain calculation. The next thing is, What is the interest on the capital which is expended ? This of course depends on the way in which the mains are laid, and different people have different ideas about how they should be laid. Many people lay mains at present with stranded cables. For my own part I cannot see what is the object of doing this ; it is the most expensive form in which you can produce your copper, and really nothing is to be gained. It seems to me simply to arise from the fact that cables we used previously were submarine cables, and certainly they are of advantage there ; but why they should be used on land, where there is no strain, I see no earthly reason. Others think they should be laid in massive bars of semi-circular shape, covered with bituminous compound ; others in flat sheets laid in troughs. At any rate, every person differs from every other, and consequently every person must have a different value for his cost of copper. But I have taken it as an example simply, and you need not take the value I use. Take the £100 a ton as the cost of adding an additional amount of copper to our mains after the troughs and so on have been laid. In that case the interest upon it depends upon the percentage which we allow. Now, what are we to allow ? Ought it to be 5, 7½, or 10 ? That, again, is a question for the engineer to determine for himself. But allow me to point this out, that when we are increasing the size of our mains, really we ought to be diminishing the percentage allowed for maintenance. The wear and tear is less, heating is less, the danger to insulation is less ; everything leads us to believe there is a less cost of maintenance with a large conductor than with a small one. This is a very important point. Each one must judge for himself whether to take 5, 7½, or 10 per cent. He will find with 5 per cent. the annual cost is 1·27, at 7½ per cent. 1·91, at 10 per cent. 2·55 ; so that what we have to do is to find that size of conductor which should equal the interest which we happen to consider the right interest. Supposing 5 per cent., then we have 1·27 settled, which gives 6 inches ; 7½ per cent., 1·81, about 4 or 4½ inches ; and 10 per cent., 2·55 ; between 3·5 and 4 inches for a thousand amperes. I have gone through this example carefully just to give you a clear conception of the way in which the problem is to be worked out, but I think you may very safely say that the consumption I have taken is too large. It is perfectly true that this estimate to which I have alluded includes the cost of buildings, dynamos, boilers, and other machinery, the mains, and also the annual cost of coal at 18s. per ton. Well, all these points do come in, therefore it is a question for each one to consider for himself how far these things are to be divided in this way. It may be said by some, however, that it is desirable only to look upon our plant as being fixed, and supposing we want to carry extra current on the same size of conductor, would it be wise to do so or not ?

We may ask, "With a working station, what would be the extra cost for energy wasted if we increased the current for the same section of wires ?" The answer might be given that everything is in place and paid for, except an extra engine and dynamo, and the cost of coal, oil, waste, and petty stores for the extra energy. The cost of a mechanical horse-power so reckoned is, say, 0·75d. per hour with coal at 21s. the ton, say 1·00d. for an electrical horse-power per hour, including loss of transformation, besides the cost of the dynamo, *i.e.*, 1500d., or £6·250 per horse-power per annum of 1,500 hours. The cost of dynamos is £20 per 1,000 watts of maximum output, or £7. 18s. per horse-power, which, at 15 per cent., is £1. 2s. 6d. per annum. Thus the whole annual charge per horse-power, in this way of looking at it, is :—

Power	6·250
Dynamo	1·125
Total charge	7·375

Now, we have seen above that when a conductor of one square inch section carries a current of 1,000 amperes the loss of energy per 100 yards is 3·2 electrical horse-power, which is £23·599 per annum. Our Table now becomes the following :—

Section in sq. inches.	Cost of waste energy.	Gain for 1·10in. increase.	Extra cost of mains at 5 per cent..
2·50	£9 440	£0·863	£0·635
2·75	£8·577	£0·711	£0·635
3·00	£7·866		
3·25	£7·261	£0·605	£0·635
3·50	£6·743	£0·518	£0·635

It is not fair to allow more than 5 per cent. on the extra copper, as there is no extra attention required ; in fact, probably less attention, owing to the smaller development of heat. This gives the maximum economy at 3 to 3·25 inches the 1,000 amperes. Where the cost of an electrical horse-power is 0·8d. in place of a penny (exclusive of interest and depreciation in the dynamo) the economical size comes out 2·5 square inches to the 1,000 amperes.

(To be continued.)

BRITISH ASSOCIATION MEETING, 1885.

ADDRESS TO THE CHEMICAL SECTION, BY PROF. HENRY E. ARMSTRONG, PH.D., F.R.S., SEC. C.S., PRESIDENT OF THE SECTION.

(Concluded from page 402.)

The current belief among physicists would appear to be that the dissolved electrolyte—the acid or the salt—is almost exclusively primarily decomposed (Wiedemann, "Elektricität," 1883, II. 924). We are commonly told that sulphuric acid is added to water to *make it conduct*, but the chemist desires to know why the solution becomes conducting. It may be that in all cases the "typical compound" is the actual electrolyte—*i.e.* the body decomposed by the electric current—*but the action only takes place when the typical compounds are conjoined and form the molecular aggregate*, for it is an undoubted fact that HCl and H_2SO_4 dissolve in water, forming "hydrates." This production of an "electrolytical system" from dielectrics is, I venture to think, *the* important question for chemists to consider. I do not believe that we shall be able to state the exact conditions under which chemical change will take place until a satisfactory solution has been found.

F. Kohlrausch (*Pogg. Ann.*, 1876, 159, 233) has shown that, on adding sulphuric acid to water, the electric conductivity increases very rapidly until when about 30 per cent. of acid is present a maximum (6,914) is attained ; conductivity then diminishes almost as rapidly, and a minimum (913) is reached when the concentration corresponds with that of a monohydrate (H_2SO_4, OH_2) ; from this point conductivity increases somewhat to (1,C31 at 92·1 per cent. H_2SO_4), and then again falls, and is probably zero for the pure acid ; on adding sulphuric anhydride to the acid conductivity again increases. Solutions of other acids and of a number of salts—chiefly deliquescent and very soluble salts—also exhibit maximum conductivity at particular degrees of concentration. In no other case has the existence of two maxima, such as are observed in solutions of sulphuric acid, been established ; but probably this is because the experiments either have not been, or cannot well be, carried out with pure substances or very concentrated solutions. Solutions of less soluble salts increase in conductivity as the amount of salt dissolved increases.

Kohlrausch has suggested, as an explanation of the influence of the "solvent" on the conductivity of an "electrolyte," that in a solution the ions which are being transferred electrolytically come less frequently into collision than would be the case in the pure substance. There is therefore less opportunity for the formation of new molecules, and the ions are able to travel farther before entering into combination.

Regarding the question from a chemist's point of view, however, I cannot help thinking that this explanation is scarcely satisfactory or sufficient; and I cannot resist the feeling that the production of electrolytically conducting solutions from dielectrics is in some manner dependent upon the occurrence of chemical action. If the composition of the solutions of

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maximum conductivity be calculated,* it will be seen that they contain but a limited number of water molecules; thus the solution of sulphuric acid of maximum conductivity (at 18°) contains 30·4 per cent. of acid, and therefore has the composition $H_2SO_4 : 12·4\ H_2O$ (approximately); for nitric acid the ratio is 1 : 8; for acetic acid it is about 1 : 17. Now, it is highly remarkable that the solutions of maximum electric conductivity are also very nearly those in the formation of which nearly the maximum amount of heat is developed; this will at once be obvious on comparison of the curves given by Thomsen ("Thermochemische Untersuchungen," Vol. III.), and by Kohlrausch. In the chemist's experience, the point of maximum heat development is usually near to the point of maximum chemical change, and I think, therefore, that we are justified in concluding that, even if electrical conductivity be not a maximum at a particular concentration on account of the presence of a particular hydrate (belonging to the class of molecular aggregates) in maximum amount, at all events the "structure" of the system is especially favourable, and the "chemical influence" exerted by the one set of molecules upon the other is at a maximum at the point of maximum conductivity. The fact that the amount of sulphuric acid required to form a solution of maximum conductivity increases with temperature—

Temp.	0°	10°	20°	30°	40°	50°	60°	70°
Per cent.	30·2	30·9	31·7	32·5	33·5	34·1	34·5	35·4

and also the fact that the maxima and minima of conductivity tend to become obliterated with rise of temperature (Kohlrausch), are both in accordance with the view that conductivity is in some way dependent upon chemical compsoition, as the effect of rise of temperature would be to cause the dissociation of hydrates such as I have referred to. The increase in conductivity of aqueous solutions with rise of temperature would appear to be against the view here put forward; but it is probable that this may be largely due to diminution in viscosity and increase in the rate of diffusion.

Our knowledge of the binary metallic compounds, which are generally admitted to be electrolytes *per se*, also affords evidence, I think, of an intimate relation between chemical constitution and "electrolysability." It has been pointed out (comp. L. Meyer, "Theorien d. mod. Chemie," 4th ed. p. 554) that whereas all the metallic chlorides and analogous compounds which cannot be electrolysed are easily-volatile bodies, the electrolysable metallic chlorides, &c., are fusible only at high temperatures. A careful discussion of the various known cases does not, however, justify the conclusion that decomposition takes place, or not, according as the temperature at which the body assumes the liquid state—and at which, therefore, there is full opportunity given for electrolysis to take place—is high or low, especially as recent observations show that electrolysis may take place prior to fusion. But it is especially noteworthy that many of the chlorides, &c., which are electrolytes, undoubtedly contain more than a single atom of metal in their molecules; indeed, after careful consideration of the evidence, I am inclined to go so far as to put forward the hypothesis *that among metallic compounds only those are electrolytes which contain more than a single atom of metal in their molecules.* No difficulty will be felt in granting this of cuprous and stannous chlorides, and even of cadmium, lead, silver, and zinc chlorides; but opinions will differ as regards the metals of the alkalies and alkaline earths.† Assuming the constitution of metallic electrolytes to be such as I have suggested, it is not improbable that on electrolysis a part only of the metal is determined to the one pole, the remainder being transferred along with the negative radical to the opposite pole. Hittorf, indeed, has already put forward this view in explanation of the remarkable results he obtained on determining the extent of transfer of the ions in aqueous and alcoholic solutions of the chloride and iodide of cadmium and zinc.

Again, an argument in favour of a connection between chemical constitution and electrical conductivity is the fact that carbon, sulphur, selenium and *phosphorus* each exist in conducting and non-conducting modifications, as it can scarcely be doubted that the so-called allotropic modifications of these elements are differently constituted.

It appears, as I have already said, to be the current belief that when aqueous solutions are submitted to electrolysis, as a rule the dissolved substance, and not the water, is the actual electrolyte. Without reference to the question I have raised as to the constitution of an electrolyte, it appears at least doubtful whether this view can be justified by appeal to known facts; at all events, I have failed to find satisfactory evidence that such is the case. Moreover, as sulphuric anhydride dissolves in water with considerable development of heat, it would appear that more work has to be done to separate hydrogen from sulphuric acid than to separate it from water; on this account we might expect that the water rather than the acid would be decomposed. Are not perhaps both affected according to the proportions in which they are present? The marked variation in the extent to which the negative ion is transferred to the positive pole, as observed by Hittorf, when solutions of different degrees of concentration are electrolysed, would appear to support this view. The difference in the products, according as dilute or very concentrated solutions of sulphuric acid are used, may also be cited as an argument that the chemical changes effected vary with the concentration; but, on the other hand, it is quite possible that the observed differences may result from the occurrence of purely secondary changes. Ostwald has recently put forward the view that one *or more* of the hydrogen atoms of certain acids are split off according to the concentration of the solution.

*Formula.	Formula Weight.	% in solution of max. con.	Composition in approximate mol. ratios.	Conductivity.
HNO_3	63	29·7	1 : 8	7330
HCl	36·4	18·3	1 : 9	7174
H_2SO_4	98	30·4	1 : 12·4	6914
H_3PO_4	98	46·8	1 : 6	1962
$C_2H_4O_2$	60	16·6	1 : 17	15·2
KOH	56	28·1	1 : 8	5995
NaOH	40	15·2	1 : 12·7	3276

† We may regard as evidence in support of this explanation the fact that neither beryllium chloride, which fuses at 600°, nor mercuric chloride is an electrolyte, as both of these, at temperatures not far removed from their boiling points, exhibit the simplest possible molecular composition. Clarke's recent interesting observations on mercuric chloride and iodide do not, I think, suffice to prove that these compounds are electrolytes; it is more than probable that electrolysis is preceded by the formation of mercurous compounds. Even an aqueous solution of mercuric chloride does not conduct appreciably better than water (Buff).

I call attention to this because I conceive that it has a most important bearing on the discussion of the nature of the chemical changes which occur during the dissolution of metals. Formerly it was said that when zinc acts upon dilute sulphuric acid, the zinc displaces the hydrogen of the water and the resulting zinc oxide dissolves in the acid, forming zinc sulphate; the modern explanation advocated by most chemists has been that the metal directly displaces the hydrogen of the acid; in fact, that this is the nature of the change whenever an acid is acted upon by a metal. If in a solution of sulphuric acid, of whatever strength, the acid be the actual electrolyte, I imagine that we are right in accepting this modern view; but if the water be the electrolyte, we must, to be consistent, return to the view that the oxide—more probably in most cases the hydroxide—is the primary product. And if it can be shown that during electrolysis both water and acid, according to circumstances—concentration, E.M.F., &c.—undergo change, it will be necessary to teach that in a similar manner the action of metals on acids is no less complex. Our views on the action of metals on concentrated sulphuric acid, and on solutions of nitric acid of various strength, must also materially depend on the interpretation of the behaviour of these acids on electrolysis with varying electromotive forces.

Having thus fully explained why I venture to think that Helmholtz's definition that "electrolytes belong to the class of typical compounds, not to that of molecular aggregates" is somewhat open to question, it now becomes necessary to make some slight reference to the constitution of these so-called molecular aggregates. Although opinions differ widely as to the definition to be given of a typical or atomic compound, and of a molecular compound or aggregate, the majority of chemists appear to agree that we must recognise the existence of two distinct classes of compounds. Prof. Williamson, in his address to this section at the York meeting (1881), entered at length into the discussion of this question, and in very forcible terms objected to the recognition of molecular combination as something different from atomic combinations; in this I, in the main, agree most fully with him. He further said that he had been led to doubt whether we have any grounds for assigning any limits whatever to atomic values, and he adduced a number of cases which, in his opinion, afforded illustration of a capability of elements to assume greater atomic values by combining with both negative and positive atoms than with atoms of one kind only; for example, he cited the compounds K_2CuCl_4 and K_2HgCl_4 as proof that copper and mercury may assume hexad functions; the compound K_2AgI_3 as an illustration that silver may act as a pentad; and the compounds $KAsF_6$ and K_2AsF_7 were regarded by him as evidence of the heptadicity and nonadicity of arsenic.

I have long been of opinion that the experimental investigation of this question is of great importance, and I believe that it must ere long attract the attention it deserves. The problem will be solved, not by discussions on the fertile theme of valency, but by determining the structure—the constitution—of bodies such as were referred to by Prof. Williamson.

My own view on the question is a very decided one. So far as the mere definition of valency is concerned, I entirely agree with Lossen; and, as I have said, I hold with Prof. Williamson that in all compounds the constituents are held together by atomic affinities, and atomic affinities only, but I believe that the formation of so-called molecular compounds is mainly due to peculiarities inherent more especially in the negative elements—*i.e.*, the non-metals and metalloids, and not in the positive elements—the metals; in other words, to the fact that, as was first pointed out, I believe, by Lothar Meyer, the negative elements tend to exhibit a higher valency towards each other than towards positive elements. The view I take, then, is, that in the majority of so-called molecular compounds the patent molecules are preserved intact in the sense in which a hydrocarbon radical, such as ethyl, is preserved intact in an ethyl compound, being held together by the "surplus affinity" of the negative elements. Thus I would represent the compounds K_2CuCl_4 and K_2HgCl_4 as containing copper and mercury of the same valency as the metal in the parent chloride, and regard them as compounds of the radicals ($CuCl_2$), ($HgCl_2$), and (KCl); a view which may be expressed by the formulæ

$$Cu\begin{matrix}Cl\,.\,ClK\\Cl\,.\,ClK\end{matrix} \qquad Hg\begin{matrix}Cl\,.\,ClK\\Cl\,.\,ClK\end{matrix}$$

The arsenic compounds referred to may be similarly represented

$$F_4AsF\,.\,FK \qquad F_3As\begin{matrix}F\,.\,FK\\F\,.\,FK\end{matrix}$$

We do not hesitate to attribute to the so-called double cyanides this order of structure, without in any way supposing that the metal changes in valency. Evidence that the "constituent radicals exist unchanged in molecular compounds" is afforded by facts such as that ferrous and potassium chlorides, for example, form a compound which obviously is still ferrous, being of a green colour, which would hardly be the case if the valency of the iron were increased; and that in like manner the compounds formed from stannous chloride manifest all the properties of stannous derivatives.

Whatever be the nature of chemical affinity, it is difficult to resist the conclusion that the "charge" of a negative radical especially is rarely, if

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ever, given up all at once, that its affinity is at once exhausted. It would also appear that the amount of residual charge—of surplus affinity—possessed by a radical after combination with others depends both on its own nature and that of the radical or radicals with which it becomes associated. Differences such as are observed in the composition and stability of the hydrates of the salts of an acid—the sulphates, for example—clearly point to this. Other illustrations are afforded by the manner in which chlorhydric acid yields chlorhydrates of some metals and chlorides of others.*

It is noteworthy, however, that often those elements which from the ordinary point of view are regarded as possessed of feeble affinities are those which manifest the greatest tendency to form molecular compounds. Thus, it is commonly held that of the three elements, chlorine, bromine, and iodine, chlorine has the highest and iodine the lowest affinity, and this view accords well with the recent observations of V. Meyer on the relative stability of their diatomic molecules at high temperatures; but nevertheless we find that the compound which HI forms with PH_3 is far more stable than that of HBr or HCl with this gas; and it is well known that mercuric *iodide* has a much greater affinity for other iodides than have mercuric bromide and chloride for the corresponding bromides and chlorides.†

The recognition of the peculiarity in the negative elements to which I would attribute the formation of molecular compounds must, I think, exercise an important influence in stimulating and directing the investigation of these compounds and of compounds other than those of carbon; in the near future the determination of the structure of such compounds should occupy an important share of the chemist's attention. It will perhaps afford a clue in not a few cases which are not altogether satisfactorily interpreted in accordance with the popular view of valency. I may instance the formation of (?) polymeric metaphosphates, of complex series of silicates and tungstates, and of compounds of hydrocarbons with trinitrophenol. It may even serve to explain some of the peculiarities of the more complex carbohydrates.

It is one of the most clearly established of the "laws of substitution" in carbon compounds that negative radicals tend to accumulate; numerous instances are afforded by the behaviour of paraffinoid compounds with chlorine, bromine, and oxidising agents, and by that of unsaturated paraffinoid compounds when combining with hydrogen bromide and iodide. The special affinity of negative elements for negative is not improbably the cause of this accumulation. A similar explanation may perhaps be given of some of the peculiarities which are manifested by benzenoid compounds.

I would even venture to suggest that in electrolysing solutions the friction arising from the attraction of the ions for each other is perhaps diminished, not by the mere mechanical interposition of the *neutral* molecules of the solvent—in the manner suggested by Kohlrausch—but by the actual attraction exercised by these molecules upon the negative ion in virtue of the affinities of the negative radicals.

One result of increased attention being paid to the investigation of problems such as I have indicated will probably be that we shall be called upon to abandon some even of our most cherished notions. I would suggest, for example, that it may become necessary to regard nitrogen peroxide not as a mixed anhydride of nitrous and nitric acids, but as a compound of two NO_2 groups; its conversion into nitrite and nitrate affords no proof of its constitution, as chlorine peroxide, ClO_2, which exhibits no tendency whatever to combine with itself, also yields both chlorite and chlorate. A greater shock may result from a conviction arising that not only carbon dioxide, but sulphur dioxide, and perhaps even sulphur trioxide, dissolve in water, forming *hydrates*—$SO_2{\cdot}OH_2$, $SO_3{\cdot}OH_2$—not *hydroxides*. In recent times, in discussing questions of this kind we have perhaps often been led to attach too much importance to the argument from analogy; it is not improbable that, especially in the case of compounds other than those of carbon, chemical change involves change in structure more frequently than we are apt to believe.

It is possible that a precise estimate of what, for want of a better name, I have spoken of as residual affinity, may sooner or later be obtained, if the view Prof. Lodge has propounded in his paper "On the Seat of Electromotive Forces in a Voltaic Cell" be correct, that the cause of the Volta effect is the *tendency to chemical action* between the bodies in contact; that, for example, chemical strain at the air-contacts is the real cause of the apparent contact force at the junction of two metals in air. Prof. Lodge, if I understand his argument, appears to assume that the air effects are in some way dependent on the presence of "dissociated oxygen atoms." I think this is probably an entirely unnecessary assumption. Of late years, no doubt it has been the fashion to attribute the occurrence of changes of various kinds to the presence of products of dissociation, but probably to a very unnecessary extent. Recent investigations to which I have alluded show that there are other factors of extreme importance; for example, that water must be present in order to render a mixture of carbonic oxide and oxygen explosive. Again, the observations of V. Meyer and Langer have shown that, whereas chlorine *violently attacks* platinum at low temperatures, it is *without action* upon it at temperatures between about 300° and 1,300°, but then *again begins to act* upon it, the action becoming violent at 1,600° to 1,700°. I have little doubt that the action at low temperatures is dependent upon the presence of moisture; if it were due to dissociated chlorine atoms, the action should increase with rise of temperature without break. In short, I see no reason to assume that oxygen at ordinary temperatures consists of other than diatomic molecules. Assuming Prof. Lodge's view to be correct, the strain exists in virtue of the attraction which the oxygen molecules exert upon the metal molecules. On this assumption, I can well understand that the method of calculation followed by Prof. Lodge will not uniformly lead to satisfactory results. The "heat of combination" is not necessarily a measure of "affinity." The values are in all cases algebraic sums of a series of values, scarcely one of which is known, and, as I have already pointed out, the affinities of the molecules are by no means always of the same order as the affinities of the constituent atoms; for example, in all probability oxygen-stuff has a higher absolute affinity than sulphur-stuff; chlorine-stuff a higher absolute affinity than iodine-stuff, yet iodine and sulphur compounds more often than not seem to exhibit more residual affinity than chlorine and oxygen compounds. So that, from Prof. Lodge's point of view, chlorine would have the higher and iodine the lower contact value; whereas, from my point of view, the reverse might often be the case. I point this out because it appears to me that we here have an opportunity of testing the question experimentally; and seeing that it is possible practically to prevent chlorine from attacking metals by excluding moisture, I do not take the hopeless view that Prof. Lodge and others seem to hold regarding the possibility of settling the important question of pure contact *versus* chemical action by appeal to experiment. I may also point out that according to my hypothesis it is possible that the metals may exert a considerable attraction for each other, especially those having monatomic molecules; many alloys are undoubtedly compounds; possibly not a few are compounds of the "molecular aggregate" class.

To return now for but a few moments to the subject of chemical change and its intimate connection with electrical phenomena. One application I would make of the views here put forward would be to explain the superior activity of bodies in the *nascent state*, and in particular of nascent-hydrogen. Briefly stated, I believe it to consist in the fact that nascent hydrogen is hydrogen in circuit—hydrogen in electrical contact with the substance to be acted upon. The experiments of Faraday and of Grove afford the clearest evidence that in order to bring about action between hydrogen and oxygen at ordinary temperatures it is merely necessary to make them elements in a voltaic circuit. The difference in the effects produced by "nascent hydrogen" from different sources is, I imagine, attributable to the variations in E.M.F., which necessarily attend variations in the constituent elements of the circuit.

It is not so easy, however, as yet to explain some of the changes which take place at high temperatures. Mr. Dixon's experiments have proved that a mixture of carbonic oxide and oxygen is non-explosive, but that explosion takes place if moisture be present, the velocity of the explosive wave depending upon the amount of water present. When the mixture of the two gases is "sparked" change takes place, but only in the path of the discharge. Mr. Dixon considers "that the carbonic oxide becomes oxidised at the expense of the water, the hydrogen *set free* then becoming reoxidised." M. Traube, who in a series of papers has called attention to the importance of water in promoting oxidation, has suggested that the oxygen and carbonic oxide together act on the water, forming hydrogen peroxide and carbonic acid: $CO + 2OH_2 + O_2 = CO(OH)_2 + H_2O_2$; and that the peroxide then reacts with carbonic oxide to form corbonic acid: $CO + O_2H_2 = CO(OH)_2$. The carbonic acid, of course, is resolved into carbon dioxide and water ("Berichte," 1885, p. 1,890). Traube actually shows that traces of hydrogen peroxide are formed during the combustion. It appears to me that the water may exercise the same kind of action as it (or rather dilute sulphuric acid) exercises in a Grove gas battery, and that its hydrogen does not become free in any ordinary sense. The production of hydrogen peroxide is not improbably due to a secondary simultaneous change.

Unlike a mixture of carbonic oxide and hydrogen, a mixture of hydrogen and oxygen is violently explosive. If we assume that in both cases the reacting molecules are electrolysed by the very high E.M.F. employed, and that the atoms then combine, it is difficult to explain the difference in the results. Does it arise from the fact that hydrogen is an altogether peculiar element? Or are we to attribute it to an influence which water itself exercises upon the formation of water from hydrogen and oxygen—as in the Grove gas battery? It is noteworthy that the velocity of the explosive wave in electrolytic gas, according to Berthelot and Vieille, is a close approximation to the mean velocity of translation of the molecules in the gaseous products of combustion calculated from the formula of Clausius (H. B. Dixon, *Phil. Trans.*, 1884, p. 636). And this is also true of mixtures of carbonic oxide and oxygen, and of nitrous oxide and oxygen with hydrogen. May we therefore assume, as the velocity corresponds with that of the products, that the water exercises the important office of inducing change throughout the mass, and not that the hydrogen is peculiar? I am tempted here to suggest that perhaps the "induction" observed by Bunsen and Roscoe in a mixture of chlorine and hydrogen is due to the occurrence of a change in which a something is produced which then promotes reaction between the two gases. I here assume that there would be no action between the pure gases.

If I have allowed myself to flounder in among these difficult questions it is not because I feel that I am justified in speaking with authority, but

* The name chlorhydric acid is here applied to the compound $HCl(OH_2)x$—probably $x=1$—which, according to Thomsen, is present in an aqueous solution of hydrogen chloride. It would be an advantage if we ceased to speak of HF, HCl, HBr, HI, as acids, and always termed them hydrogen fluoride, chloride, bromide, and iodide respectively. The names hydric chloride, bromide, &c., might with equal advantage be altogether abandoned; hydrochloric acid is objectionable, as suggesting a relation to chloric acid. The names fluor-, chlor-, brom-, and iodhydric, as applied to the *acids* present in aqueous solutions of the hydrides, are especially appropriate as indicating that they are compounds containing the radical water—that they are hydrates; indeed, it would be well to restrict the use of hydric and hydro- to bodies of this kind, and to speak of hydrides as hydri-, not as hydro-, derivatives. It would then be possible to give comparatively simple names even to complex hydrates.

† Thomsen gives the values in heat units as—

$HgCl_2$, 2KClAq	= −1380
$HgBr_2$, 2KBrAq	= 1640
HgI_2, 2KIAq	= 3450
$HgCy_2$, 2KCyAq	= 8830

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in the hope that I may be the "fool," and that the "angels" who are well able to discuss them will be led to do so without delay; for chemists are anxiously awaiting guidance on matters such as I have referred to.

Attention must, however, be directed to the study of electrical phenomena by the recent publications of Arrhenius and of Ostwald (*Journal für Praktische Chemie*, 1884, 30, 93, 225; 1885, 31, 219, 433), and especially by the statement put forward by the latter that the rate of change under the influence of acids (in hydrolytic changes) is strictly proportional to the electrical conductivities of the acids. There cannot be a doubt that these investigations are of the very highest importance.

I trust that in the discussions which we are to have on molecular weights of liquids and solids, and on electrolysis, there may be a free exchange of opinion on some of the points here raised. My reason for selecting these subjects for discussion in this section will have been made sufficiently clear, I imagine. Last year, in the Physical Section, the idea assumed shape which had long been latent in the minds of many members of the Association, that it is unadvisable, as a rule, to encourage the reading of abstract papers, which rarely are, or can be, discussed. Two important discussions were *introduced* by Profs. Lodge and Schuster. We must all cordially agree with Prof. Lodge's remarks on the importance of discussing subjects of general interest at these meetings. It appears to me, however, that even a more important work may often be accomplished if the discussion consist of a series of papers which together form a monograph of the subject. I have endeavoured to carry this idea into practice on the present occasion, and a number of friends have most kindly consented to assist. Unexpected difficulties have arisen, and probably we shall none of us succeed in doing all we might wish. I trust, however, that the section will approve of this first attempt sufficiently to justify my successors in this chair in adopting a similar course.

I much regret that is impossible for me to attempt any review of recent work in chemistry. Not a few really important discoveries might be chronicled, and the patient industry of many who have toiled long to win results apparently insignificant should have been mentioned with high approval. A few remarks I will crave permission for, as regarding the general character of the work being done by chemists, and regarding that which has to be done.

Complaints are not unfrequently made in this country that a large proportion of the published work is of little value, and that chemists are devoting themselves too exclusively to the study of carbon compounds, and especially of synthetical chemistry. We are told that investigation is running too much in a few grooves, and it is said that we are gross worshippers of formulæ. Most of these outbursts are attributable to that pardonable selfishness which consists in assigning a higher value to the particular class of work with which one happens to be engaged or interested in than to any other line of investigation; too frequently they result from want of sympathy with, if not absolute ignorance of, the scope and character of the work complained of. It must not be forgotten that chemical investigation, like other investigation, is to a large extent the work of genius; the rank and file must necessarily follow in the order of their abilities and opportunities; hence it is that we work in grooves. The attention paid to the study of carbon compounds may be more than justified both by reference to the results obtained and to the nature of the work before us; the inorganic kingdom refuses any longer to yield up her secrets—new elements—except after severe compulsion; the organic kingdom, both animal and vegetable, stands ever ready before us; little wonder, then, if problems directly bearing upon life prove the more attractive to the living. The physiologist complains that probably 95 per cent. of the solid matters of living structures are pure unknowns to us, and that the fundamental chemical changes which occur during life are entirely enshrouded in mystery. It is in order that this may no longer be the case that the study of carbon compounds is being so vigorously prosecuted; our weapons—the knowledge of synthetical processes and of chemical function—are now rapidly being sharpened, but we are yet far from ready for the attack. As to the value of the work, I believe that every fact honestly recorded is of value; an infinite number of examples might be quoted to prove this. No unprejudiced reader can but be struck also with the improvement in quality which is manifest in the majority of the investigations now published; at no time was more attention given to the discovery of all the products of the reactions studied, and to the determination of the influence of changes in the conditions. As regards our formulæ, those who look upon the outward visible form without proper knowledge of the facts symbolised, and who take no pains to appreciate the spirit in which they are conceived, are undoubtedly misled by them. The great outcome of the labours of carbon-chemists has been, however, the establishment of the doctrine of structure;* that doctrine has received the most powerful support from the investigation of physical properties, and it may almost, without exaggeration, be said to have been rendered visible in Abney and Festing's infra-red spectrum photographs. Some of us look forward to the extension of the doctrine of structure not only to compounds generally, but even to the "elements." The relationships between these are in so many cases so exactly similar to those which obtain between carbon compounds, which we are persuaded differ merely in structure, that it is almost impossible to avoid such a conclusion, even in the absence of all laboratory evidence.†

As the field of view opens out before us, so does the vastness of the work to be accomplished become more and more apparent; and Faraday's words of 1834 may be quoted as even more appropriate than a half-century ago:—

"Indeed, it is the great beauty of our science, CHEMISTRY, that advancement in it, whether in a degree great or small, instead of exhausting the subjects of research, opens the doors to further and more abundant knowledge, overflowing with beauty and utility, to those who will be at the easy personal pains of undertaking its experimental investigation."

* I venture here to direct attention to an extension of the acknowledged theory of structure suggested (by myself, I may say) at the close of the discussion of the van 't Hoff-La Bel hypothesis of isomerism in Miller's *Chemistry*, Vol. III. 1880 edition, p. 993. The same view was soon afterwards independently put forward by Dr. Perkin.

† F. Exner in a recent paper (*Monatshefte für Chemie*, 1885, p. 249) "On a New Method of Determining the Size of Molecules" actually put forward an hypothesis as to the structure of elements.

FIRST REPORT OF THE ELECTRICAL SUBWAY COMMISSION, NEW YORK.

The following is the full text of the Electrical Subway Commission's report to Mayor Low:—

Brooklyn, September 15, 1885.

Hon. Seth Low, Mayor of Brooklyn:—

The undersigned, appointed by you as Commissioners of Electrical Subways for the City of Brooklyn, organised as a Board on the 9th day of July, and have since held twenty-nine meetings, mostly private, and devoted to the study of the problems presented to the Board by the law under which it was created. At a considerable number of public sessions, and also by a voluminous correspondence, the views and proposals of experts and inventors have been examined; and the Board has, moreover, made itself acquainted, as far as practicable in so brief a period, with the experience of other cities having electrical subways in this country and in foreign countries. The president of the Board has made a personal examination of the various underground conduits and systems in use at Washington, D. C., and has consulted freely with those who, during the past few years, have been conducting experiments with electrical subways in that city. Neither these investigations nor the knowledge previously possessed by the individual members of the Board have rendered it possible at this early stage to announce a solution of the problem of underground electrical conductors throughout the City of Brooklyn which shall be thoroughly practicable and at the same time entirely satisfactory and complete. One solution has, indeed, been proposed by eminent authority. The General Committee on Underground Communication, composed of telegraph and telephone managers, the Governor of the State and the Mayor of the City of New York and others, referred the subject of electrical and mechanical devices to a sub-committee, of which a distinguished electrician, President Henry Morton, of the Stevens Institute of Technology, was chairman, and this sub-committee reported in March, 1884, that nothing would be as good as a properly constructed tunnel of sufficient size to admit the passage of workmen and access to the wires within it; this tunnel to be connected with conduits of sufficient capacity for lateral wires. Another sub-committee of the same general committee reported that there was no law of the State under which a company could construct such a tunnel and conduit system, with the view of leasing the space or the conductors, and it seems to be admitted that no existing company would undertake it for the accommodation of its own wires. That the cost would be very great is evident, and the probability is that it would be greater in Brooklyn than in New York, if the attempt were made to cover with such a system all the area of the city, since the shape of our City of Brooklyn would not permit so easily the distribution of lateral conduits from one main central tunnel.

So far as the Board has been able to learn no extensive tunnel system has anywhere been constructed for the accommodation of electrical conductors. In London, where the tunnels of the Metropolitan Underground Railway have been utilised, and in Paris, where the large sewers have served the same purpose, these subterranean channels, already existing, could be turned to account without cost, and these cases constitute no precedent applicable to a city where tunnels and suitable large sewers do not exist. Such opportunities, and likewise the opportunities offered by the structures of elevated railways, should be utilised, of course, wherever practicable. But it does not follow that nothing more can or should be done until somebody constructs a vast system of tunnels and branches. Even if that were certain to be the ultimate plan (of which this Board is by no means assured), tangible relief may be obtained in the meantime from plans less ambitious and comprehensive.

The sub-committee already mentioned examined between May 7, 1883, and March 15, 1884, about six hundred proposed plans and devices. Since the latter date many new ones have been brought forward. Their number, variety, and complexity would render the task of this Board almost interminable if that task were to be an exhaustive scientific examination of every theory or device submitted to it, coupled with experimental tests of such promising ideas as had not received the seal of successful practice. But this Board conceives its duty under the law to be to promote in every possible way relief from the evils which the law was designed to remedy, and it has therefore been from the outset desirous of approving some plan by which a beginning could be made, provided only that such a plan should be reasonably free from mechanical or other objections, and that it should not be of such a nature as to exclude improvements dictated by further experience. The consideration of the subject with a view to immediate practical action has been much simplified by the establishment of certain conclusions, based upon actual conditions in the City of Brooklyn, as well as recognised principles of electrical engineering; and it is to state these conclusions and explain in plain and non-technical language the consequent action of the Board that the present report is designed.

1. The purely electrical questions connected with underground electrical conductors are not yet satisfactorily solved. The general experience is that such conductors cost more in the beginning and less for current maintenance than overhead wires, but that they do not last as long. No

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substance used as an insulator underground has proved invariably and perfectly permanent. The expensive gutta percha covered wires employed so widely in Europe have been deemed (apart from their high cost) the best subterranean conductors; and yet wires of this kind—the same as those used by the British Postal Telegraphs—which had been for years in the underground service of the Western Union Telegraph Company in New York, have, within a few weeks past, developed a curious disease of the gutta percha coat which rapidly destroys their insulation. If material so long and so thoroughly known and tested is thus liable to fail, obviously it would not be safe to trust to materials not known or not tested by prolonged experience, no matter how confident their inventors might be of their special virtues. The practical conclusion drawn by this Board from the above proposition is that solid conduits—that is, conduits consisting of groups of wires solidly bedded in insulating material (such as asphaltic concrete or the like), should not be extensively adopted in the present state of knowledge and experience. By this it is not meant that experiments might not be cautiously tried with some such method, but such experiments should be limited in extent and prolonged in duration. Only successful operation for some years could overcome the unfavourable presumption created by past experience. In such solid conduits the single conductors have hitherto almost invariably failed, sooner or later, for one reason or another, or for no assignable reason, and when they do fail the whole agglomeration of wires and cement is useless. Repair is impossible, and the digging up of the mass to replace it is far more difficult and costly than the original excavation. In Washington, Philadelphia, New York, even in Brooklyn, there are to-day sections of underground conductors laid on this plan and abandoned in despair, but not removed. The immediate problem is thus simplified by excluding for the present solid conduits, and leaving such only as permit the renewal and removal of wires and cables.

2. It is not primarily the duty of this Board to solve electrical problems for the benefit of the electrical companies, and in judging of any system of underground connections proposed by such a company the Board is concerned with its electrical features only so far as they affect its repairs or changes, and the disturbance of the city streets which those may involve. That is to say, questions of detail concerning insulators, conductors, preventives, or remedies for induction, &c., may be safely left to the companies themselves, their interest being to secure and maintain an efficient service in these respects, provided always that the system proposed be one which will permit experiment, repair, renewal, and change without excavation. If the streets must be dug up every time an old cable or wire fails or a new one is to be tried, then it is part of the duty of this Board to know beforehand what sort of conductors, insulators, &c., will be used in any proposed system, and to approve only that system which promises in these respects the greatest efficiency and permanence. Otherwise these considerations concern the electricians and business managers of the companies only. The problem is thus further simplified by restricting it for the present to conduits only.

3. Such conduits, unless they were large tunnels, could in all probability not carry the wires for electric arc lights. No discussing of the electrical disturbance produced by currents of high intensity upon neighbouring conductors will be undertaken. Nor does the Board here pass a scientific judgment upon various suggested remedies. A number of plans have been submitted to the Board involving the collection of telegraph, telephone, and arc light wires in the same conduit, of small dimensions. In some cases the inventors evidently do not realise the difficulties and dangers involved; in other cases they offer ingenious remedies and protections not yet tested in practice. But this Board is not willing to approve such plans in the present state of electrical science. It is convinced that prudence requires that the electric arc light conductors should be, in the words of the New York sub-committee already referred to, "widely separated from each other, from all other classes of conductors, and from the walls of the conduit." The second of these requirements is the most important, and it simplifies the duty of the Board by dividing one problem into two, which can be separately solved. A large tunnel being deemed at present impracticable, the low tension (telegraph, telephone, &c.), conductors and the high tension conductors must be provided for in different conduits.

4. Approaching now the subject of underground conductors for telegraph and telephone service, the Board finds that the most important, and in some respects the most difficult, part of the problem in the City of Brooklyn is presented by the telephone service. The New York and New Jersey Telephone Company, operating nearly all the telephones within the city limits, owns over two-thirds of the electric conductors of all kinds strung overhead in Brooklyn, and occupies, either alone or in conjunction with the other electrical companies and with the city departments, nearly three-fourths of the poles supporting such conductors. This company, in round numbers, has 2,400 subscribers in Brooklyn, 1,900 of whom require special separate wires, the remaining 500 being grouped upon circuits, so that one wire serves several subscribers. In a few large business blocks in the neighbourhood of the City Hall subscribers are so numerous and are so likely to be always numerous, in spite of individual changes, that the wires distributed to such buildings may be regarded as permanent, and there is no difficulty in arranging for their distribution from subways without the use of aërial supports. But over the larger part of the city, particularly among residences, telephone subscribers are sparsely scattered. To require that connection should be made wholly underground with each of these would be certainly to raise the cost of the telephone service to exorbitant figures, and probably to destroy the service altogether, for the earning capacity of a telephone wire is limited to a fixed sum. No amount of business done over the wire within the city limits increases the income of the company. The charge in Brooklyn at the present time, for instance, is, for a residence, 60 dols. per annum, and the subscriber contracts for only twelve months at a time. In the spring and fall large numbers of persons change their residences and have their telephones moved; at all times new subscribers are coming in and old ones falling out. Changes due to these causes have been known to amount to several hundreds in a month, and as the business is extended these changes will become still more numerous. If complete underground connections were insisted upon in all cases, the telephone company would be obliged either to exact from its residence subscribers a heavy initial payment to cover the cost of the first connection, or a long contract of service, or both; or else it would decline to serve such subscribers. In practice, either of the two former alternatives would probably be the same as the last, since, if the company did not decline the subscriber would. In the opinion of this Board the resulting limitation of the telephone service in Brooklyn would be a serious injury to the city. That service is one of the last invented agencies of civilisation by which this city is rendered a desirable place of residence. The means of easy communication between Brooklyn and New York, or between distant portions of this city and its business and official centres, promotes its territorial extension and the increase of residence in its beautiful outlying wards. If handsome dwellings are no longer confined to the Heights, it is because of such conveniences as the bridge, the surface, elevated and rapid transit railways, and last, but destined not to be least, the growing telephone system. The existence of such a system, therefore, is a benefit to others than its subscribers for the time being, just as the existence of gas and water supply in a given street enhances the value of property on that street, even of houses not yet supplied, or of vacant lots where no houses stand.

Another consideration, however, has impressed itself upon this Board. Assuming that it were mechanically and commercially practicable to make all telephone connections completely subterranean, and that the telephone company could satisfactorily adjust the question of cost with its subscribers, the perpetual digging up of the streets and sidewalks of Brooklyn to make and unmake such connections might become a more intolerable nuisance than the aerial wires. If telephone subscribers were so numerous and so distributed that a main conduit were required in every street, this evil would be reduced to a minimum, though it would still exist. If every house contained a permanent subscriber, or if every house owner maintained the telephone service as regularly as the gas or water service, the evil would disappear. But such conditions neither exist nor impend. In the present actual condition of the Brooklyn telephone system, a combination of main subways with overhead conductors for terminal distribution is the only thing that can reasonably be undertaken.

Such a combination has been in operation for some years in Washington, D.C., where the cables from the main subways are carried at convenient points to poles, whence the single wires are distributed to subscribers. Washington, fortunately for this plan, possesses numerous lanes and alleys, in which such poles can be placed and thus be removed from the main thoroughfares. In Brooklyn, for the most part, such lanes are wanting. In permitting such a system here it would be the duty of the Board to exercise a constant vigilance of detail, with the determination of abolishing, as fast and as far as possible, all poles whatever, and of securing the location in the least objectionable places of such as seemed temporarily indispensable.

Immediately upon the organisation of the Board the New York and New Jersey Telephone Company proposed to lay in Washington-street a box conduit of creosoted wood to contain in separate compartments cables of 25, 50 or 100 wires which would be drawn in through manholes located at convenient points, and would terminate at distributing poles. The Board declined at that time to commit itself to the approval of this plan, and required of this company, as of all others operating in the city, the preparation of maps and other information necessary for a full investigation of the subject. A map showing the location of every telephone subscriber and wire in the city was prepared by the company, and the minor details of its plan, which was subsequently proposed again on a larger scale, were thoroughly discussed between the Board and the experts of the company.

As the result of these inquiries and conferences the Board has adopted the following resolutions:

Whereas the New York and New Jersey Telephone Company has submitted to this Board a plan of construction for an underground conduit to contain electrical conductors, which plan the said company proposes to carry out immediately on the following lines, viz.: On Fulton-street, from De Kalb-avenue to the City Hall, and below the City Hall, either on Fulton-street or on Washington-street, to points to be hereafter determined by this Board, the said conduit to consist of a partitioned box of creosoted timber, and the wires and cables contained therein to be connected for terminal distribution with overhead conductors at such places and to such extent only as this Board may permit;

And whereas the representatives of the Western Union Telegraph Company and the Gold Stock Telegraph Company have signified their concurrence in the said plan and their willingness to place their conductors along the said routes in the said conduit, and the said New York and New Jersey Telephone Company has agreed to give in the said conduit sufficient accommodation for the said wires, and also for the wires of the police and fire departments of Brooklyn;

And whereas the said plan of construction appears to this Board practicable, and promises to remove from the said streets a large number of the telephone and telegraph wires and poles which now encumbered them; therefore,

Resolved that this Board hereby approves the said plan of construction, subject at all times to such modifications as shall from time to time by this Board be made, and subject also to the rules and regulations not inconsistent therewith, prescribed or to be prescribed by the municipal authority having control of said streets. Provided that the number, nature, location and extent of all aerial conductors to be connected with the said subway, and of their poles or other supports, shall be determined hereafter by this Board, the present general approval of the said plan, in advance of the

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determination of details, being given by this Board in order to permit making of contracts for the materials required.

A few words in further comment on this action will complete what the Board deems it advisable to say at this time. The plan thus approved is subject to the continual control of the Board; and the approval thus given does not prevent the Board from continuing a patient examination of all other suggested plans. Since this conduit, however, will permit the experimental use of any kind of cable which the telephone or telegraph companies may prefer, the choice of such cables has been left by the Board, for the present, to the companies, and the latter have already determined to try several varieties. Persons having special conductors or insulators to recommend are therefore referred to either of the above-named companies. At the same time this Board will be glad to receive at any time from such persons statements concerning proposed conductors, &c., and will arrange for personal hearings whenever they shall seem to the Board desirable. But, pending the tests to be made by the companies, the Board does not propose to institute practical tests of new conductors. With regard to the conduit itself, the Board is satisfied that timber properly creosoted will be sufficiently durable, and this material having been proposed by the companies referred to, the Board has not felt called upon to suggest any other and more expensive one. Creosoted wood is said to be injurious to gutta percha coating brought into contact with it; and it is not unlikely that wires covered with gutta percha would have to be further protected if used in this conduit. But lead pipe containing insulated wires can be placed in it without fear of injury from creosote or moisture. Such lead cased cable could be, in the opinion of the Board, drawn into the conduit through the manholes, even if the latter were placed at greater distances apart than will probably be the case. The position and detailed construction of the manholes, together with other details of the system, will be determined hereafter, with careful reference to the local conditions on each block affected.

The objection to box conduits, that they may give opportunity for the accumulation of explosive mixtures through leakage from the gas pipes, has been duly considered, and the Board believes that effective provision can be made for the prevention of such accumulation in this conduit. A conduit of this character has been successfully operated in Brooklyn during the last nine months. It lies in Court-street, from the City Hall to Pacific-street; contains in cables 450 telephone wires, of which 250 are now in service, and the remainder are being rapidly brought into connection with aerial distributing conductors. This conduit has so far given no trouble, and has not been opened since it was laid. It is intended to open it, and carefully inspect its condition, and such an inspection may determine some points of detail in the larger system of the same general character now to be constructed.

In regulating the terminal distribution connected with the proposed conduit the Board will follow no general and invariable rule, but, considering each locality separately, will strive to reduce to a minimum the necessary amount of aerial conductors, and to cause these to be supported wherever practicable otherwise than upon poles in the streets.

INDIA OFFICE SPECIFICATION.

Specification for certain Component Parts of Standard Iron Telegraph Posts for the Government of India.

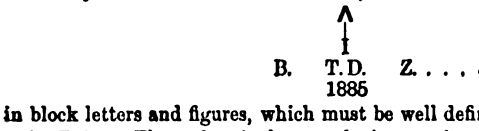
1. All the component parts are to be of the best materials and workmanship, and to be made in accordance with the drawings and patterns, which may be seen on application to the Superintendent of the India Store Depot, Belvedere-road, Lambeth, S.E.

2. *Sole Plates.*—The sole plates to be made of the best grey metal, cleanly cast and blackened. To test the fitting of the screws, 1 per cent. of the sole plates shall be screwed on to the sockets. In the event of any misfit the whole may be screwed on. By misfit in this case is meant a sole plate not entering on the screw of the socket sufficiently to take 1¼ complete turns. The thickness of the corrugated web to be 3-16 of an inch.

3. *Sockets.*—The sockets to be made of the best grey metal, cleanly cast and blackened, and in order to ensure the concentricity of the cast-iron sockets, the contractors shall have the bearings of the core barrels and seatings of the moulding boxes, with which they are made, turned and bored respectively. Five per thousand of the rough castings will be broken at the expense of the contractor, to determine their accuracy in this respect.

4. *Caps.*—The caps are to be made of the best annealed malleable cast iron. The socket in the cap is to be rimered out and gauged for size. A manufacturing margin of 1-16th of an inch, either upwards or downwards, will be allowed for the entrance of the gauge. A ring and plug gauge, corrected to the stand at the India Store Depot, will be supplied to the manufacturer, on his tender being accepted, and is to be returned to the Superintendent of the India Store Depot on the completion of the contract.

5. Each sole plate, socket, and cap is to have its distinguishing letter, the India Government mark, the letters T.D., the name of the contractor, and the year of manufacture cast on it, thus:—



in block letters and figures, which must be well defined.

6. *Tubes.*—The galvanised wrought-iron tubes are to be of B. B. Staffordshire iron, equal in quality to pattern No. $\frac{2845}{H}$ at the India Store Depot. Samples of the iron proposed to be used are to be submitted for the approval of the superintendent of the India Store Depot before the manufacture of the tubes is commenced. The letter distinguishing the size of a tube is to be punched out of the metal of the outside hoop at the bottom of the tube before it is riveted on. The inner strengthening rings of the tubes are to be driven home hard, the drawings merely showing their normal position.

7. The rivets for the galvanised wrought-iron tubes must be of such a quality that they will stand riveting cold.

8. The wrought-iron tubes and malleable iron caps to be well galvanised with pure zinc, which must be evenly deposited and free from spots.

9. The Superintendent of the India Store Depot, or his deputy, may be present during the whole process of making the component parts specified in the schedule, and they shall have every facility for seeing them during all stages of their manufacture, but samples of the finished work are to be forwarded for approval, free of expense, to the Superintendent of the India Store Depot, from time to time, as he may direct.

10. To ensure that all the component parts fit, there is in the drawings a dotted line called the "fitting line." When the posts are taken for testing purposes the Superintendent of the India Store Depot or his deputy will choose at random the component parts to be fitted together. On their being so fitted, should they find that any one component part in the total quantity either does not reach, or passes, this "fitting line" by more than 2in., they shall gauge one per 1,000; if they find another misfit they shall gauge 10 per 1,000, and a third out of gauge will cause the whole quantity to be gauged. In such case the portions to be gauged are the outer upper diameters of the sockets, and the inner lower, and the outer upper diameters of each tube, except tube A, which must be gauged for inside diameters at both ends.

11. The following table gives the minimum breaking weight and minimum weight at which each size of a complete post of two galvanised tubes and a socket may take a permanent set of a curve with a versed sine of half an inch:—

Size.		Breaking Weight.	Weight for Working Load and Permanent Set of not more than half inch.
Tube.	Socket.		
		lbs.	lbs.
A, Z with	Z	400	274
A, B ,,	B	500	344
B, C ,,	C	840	576
C, D ,,	D	1,500	1,033
D, E ,,	E	2,400	1,650

These are the actual pulls or dead loads at the line of wires when the posts are in working order or vertical, but, as the whole are to be tested horizontally, two-fifths of the average weight of the two tubes, taken in even pounds, is to be deducted for the overhanging weight of the post itself.

12. The component parts being ordered singly, the tests for minimum breaking strength, and also for working strength and permanent set, are to be determined exactly according to the foregoing table, and, where needed, the necessary lengths to make out the full length shall be furnished for purposes of testing by the contractor. The strength of the A 5ft. and of the Z tubes shall in all cases be at least equal to that specified for the B, C posts, both for the minimum breaking strain and also for the working strain giving the permanent set.

13. One per 1,000 of the galvanised tubes will be tested up to destruction. Should they not all give the required test, one per 100 must be tested to the minimum breaking strain. If then one per 100 should break at less than the minimum breaking strain, 10 per cent. of the quantity submitted for examination must be tested to the minimum breaking strain, and, if it be found from this that more than one per cent. has broken at less than the minimum breaking strain, the whole must be absolutely rejected.

14. The tests will be conducted as follows:—The tubes and sockets to be tested shall be fitted together, and the whole laid horizontally, so that the total weight shall rest upon a support at the ground line of the socket, viz., one foot from the bottom of the lower galvanised wrought-iron tube, and no part of the support is to be brought nearer the bottom of the lower tube than one foot, a shackle or strap holding down the socket at the bottom end, the post being thus supported on its working fulcrum. The test load shall then be hung on at the line of brackets, or one foot from the top of the post.

15. In testing for permanent set, the tubes and sockets shall be fixed in the same way as described above, and the working or dead permanent set test load, as shown in the above table, shall be hung on the post at the line of brackets, or one foot from the top end, and with this load the permanent set, measured as a versed sine from a chord stretched from the bottom to the top of the galvanised wrought iron portion of the post, after the weight is removed, shall not exceed half an inch.

16. The testing shall be performed by the Superintendent of the India Store Depot or his deputy, for which purpose the contractor must supply all necessary machinery, apparatus, a complete set of gauges and templates, convenience, labour and assistance of every kind required for the purpose, without making any claim or charge for the same, it being distinctly understood that these expenses are included in the prices stated in the tender. All tubes or sockets broken or otherwise destroyed in

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testing, and any additional lengths required, as mentioned in paragraph 12, to be at the expense of the contractor. All testing apparatus, &c., to be under the control of the Superintendent of the India Store Depot, or his deputy, during the period of examination.

17. The galvanised caps to be packed in cases made of 1in. (full) deal, with two battens each top and bottom, and to be bound with 1in. hoop iron. Each case to contain 25 of the A or B size, or 10 of the C size. The packing to be done to the entire satisfaction of the Superintendent of the India Store Depot or his deputy. Instructions for marking the cases will be forwarded by the Superintendent of the India Store Depot when the stores have been approved. Should any damage be discovered on the arrival of the stores in India, which may be attributable in any way to defective packing, the contractor will be held responsible for any loss that may arise therefrom.

18. Proper accommodation, under the control of the Superintendent of the India Store Depot or his deputy, must be provided by the contractor for the storage of approved, and the distinct and safe custody of rejected, stores, until finally disposed of.

The following is the schedule to the specification :—

Standard Iron Telegraph Posts, Component Parts.	Pattern. No. at India S. Dept.	Quantity required for				Weight of each part.
		Calcutta.	Bombay.	Madras.	Total.	
	For make	No.	No.	No.	No.	ct. q. lb. oz.
Caps, A	A 1884	—	—	2,700	2,700	0 0 2 6
,, B	B 1884	—	18,800*	11,600	30,400	0 0 3 1
,, C	C 1883	—	700	400	1,100	0 0 5 14
Tubes, A, 5 feet	A 1884	600	1,200	600	2,400	0 0 16 0
,, A, 8 ,,	A ,,	—	—	2,000*	2,000	0 1 1 0
,, B ,, ,,	B ,,	—	13,700*	8,100	21,800	0 1 22 0
,, C ,, ,,	C ,,	—	9,600*	6,700	16,300	0 2 13 0
,, D ,, ,,	D ,,	150	325	—	475	0 3 12 0
,, E ,, ,,	E ,,	115	50	190	355	1 0 16 0
,, Z, 5 ,,	Z ,,	—	6,500	1,940	8,440	0 1 1 0
Sockets, B	B ,,	—	400*	1,800*	2,200	0 2 10 0
,, C	C ,,	—	—	6,000	6,000	0 3 8 0
,, D	D ,,	—	230	—	230	1 1 4 0
,, E	E ,,	130	50	190	370	2 1 10 0
Sole plates, B	B ,,	—	200*	1,200*	1,400	0 1 4 0
,, ,, C	C ,,	—	—	6,700	6,700	0 1 4 0
,, ,, D	D ,,	—	230	—	230	0 1 17 0
,, ,, E	E ,,	150	50	180	380	0 2 2 0

The quantities marked * are required in advance of the rest. The tender should state the earliest date by which the quantities so marked can be delivered, and also by what date the contract could be completed.

Tenders, addressed to the Secretary of State for India in Council, with the words "Tender for Parts of Telegraph Posts" on the envelope, must be delivered at the India Office, Westminster, S.W., before 2 p.m. on Tuesday, the 20th inst.

LEGAL.

Hatchett's Hotel v. Verity and Sons.

In the Chancery Division, on the 6th instant, before Mr. Justice Mathew, vacation judge, Mr. Warmington, Q.C., applied on behalf of the plaintiffs to continue an interim injunction originally granted by Vice-Chancellor Bacon and renewed by Mr. Justice Mathew on 25th September, restraining the defendants from presenting a petition for the winding up of the plaintiff company. He said the grounds of his application were that the claim of the defendants was disputed, and that the company was not insolvent. The real object of the defendants was, by the winding-up process, to put an undue pressure on the company. Messrs. Verity and Sons were electricians, and under a special contract with the company, they undertook to supply the hotel in Piccadilly with the electric light. They were to do the work to the satisfaction of the architect, which had not been done. The company had found the defendants £1,000, and the latter now claimed a further sum of £1,134. The company said the defendants had no title to sue, because they had not completed the contract ; secondly, because what they had done had been improperly done, which was supported by an affidavit from Mr. Joel, electrician ; and, thirdly, because the company was not insolvent.

Mr. Bramwell Davis, for the defendants, said the plaintiffs had not offered any security for the debt.

Mr. Warmington said the ordinary course for the recovery of a debt was to bring an action.

The Judge, to the plaintiffs' counsel : Can you offer half the amount of the debt as security ?

Mr. Warmington said he was in the judge's hands.

Mr. Davis said the work was done according to the state of the science of electricity at the time the contract was entered into ; but the learned judge knew that the science was advancing from day to day. The lighting of the hotel was completed in January, and had been continued ever since. He also urged that statements which had been made at the meetings of the hotel company tended to show that the company was insolvent. He said the defendants only wished to be secured for the debt. He would leave the matter in the judge's hands ; but he thought the company should offer £800 as security.

The Judge directed that that amount should be deposited in court in the joint names of both parties, and said he would refer all the matters in dispute to arbitration, with liberty to apply to himself in court in case of any difficulty arising. Costs would be reserved, to be disposed of in chambers after the arbitration.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Oct. 7.		Business Done Week Ending Oct. 7. Highest.		Lowest.	
Anglo-American	29½,	30½	..... 30½	.....	29½	
Do. Preferred	50,	51	..... 50½	.....	49½	
Do. Deferred	7⅞,	8¼	..... 8¼	.....	8	
Brazilian Submarine	10⅜,	11⅛	..... 11 1-16	.....	11	
Cuba	12,	12½	..... 12½	.....	—	
Do. Preference	18,	19	..... 18¾	.....	—	
Direct Spanish	1½,	2	..... —	.....	—	
Do. Preference	11½	12	..... —	.....	—	
Direct United States Cable	8¼,	9	..... 8⅝	.....	8⅝	
Eastern Telegraph	11½,	11½	..... 11 7-16	.....	11½	
Do. 6 per Cent. Preference	13½,	14	..... 13 13-16	.....	13½	
Do. 5 per Cent. Debentures, 1899	105,	108	..... 107½	.....	—	
Eastern Extension	12½,	12⅞	..... 12⅞	.....	12½	
German Union	9,	9½	..... —	.....	—	
Globe Telegraph and Trust	6⅞,	7	 7	.....	6⅞	
Do. Preference	13,	13½	..... 13 3-16	.....	12⅝	
Great Northern	13⅜,	14½	..... 14⅜	.....	13⅜	
Indo-European	31,	32	 31	.....	30½	
Reuter's	7½,	8	..... —	.....	—	
Submarine	200	210	 200	.....	—	
West India and Panama	⅝,	¾	..... —	.....	—	
Do. 1st Preference	8,	8½	..... 8⅜	.....	8½	
Western Brazilian	5⅜,	5⅝	..... —	.....	—	
Western Union 7 per Cent. 1st Mortgage	120,	124	..... —	.....	—	
Do. 6 per Cent. Sterling Bonds	100,	104	..... —	.....	—	

TELEPHONES.

Consolid. Telephone and Maintenance	13-16,	15-16	.....	⅞	.....	—
Oriental	¼,	⅜	.....	—	.....	—
United Telephone	11½,	12	.....	11⅞	.....	11⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1⅝,	2¼	.....	—	.....	—
Do. (fully paid)	3½,	4	.....	3⅝	.....	—
Hammond Light (£3 15s. paid)	1-16	3-16	.....	—	.....	—
Swan	½,	¾	.....	—	.....	—
Maxim-Weston	3-16,	5-16	.....	¼	.....	—

MISCELLANEOUS.

Telegraph Construction	85½,	86½	.....	86½	.....	86
India Rubber, Gutta Percha, and Telegraph Works	22½,	23½	.....	23	.....	22½

TRAFFIC RECEIPTS FOR SEPTEMBER, 1885.

Companies.	Sept., 1885.	Sept., 1884.	Increase.	Decrease.
Brazilian Submarine	—	—	—	—
Cuba Submarine	2,100	2,163	—	63
Direct Spanish Telegraph	1,770	1,663	107	—
Eastern Telegraph	47,849	50,913	—	3,064
Eastern Extension	41,845	41,590	255	—
Great Northern	25,200	—	—	—
West Coast of America	3,680	—	—	—
Western and Brazilian	—	—	—	—

UNIVERSITY COLLEGE OF NORTH WALES, BANGOR.

SESSION 1885-6 will open on FRIDAY, OCTOBER 2.

DEPARTMENTS OF PHYSICS, CHEMISTRY, AND BIOLOGY.

Physics .. { *Professor*, A. Gray, M.A. / *Demonstrator*, D. M. Lewis, M.A.

Chemistry { *Professor*, J. J. Dobbie, M.A., D.Sc. / *Demonstrator*, G. Macgowan, Ph.D. (Leipzig).

Biology .. *Lecturer*, R. W. Phillips, B.A., B.Sc.

The Classes and Laboratory Courses of this College are arranged to suit the requirements of Students preparing with a view to the Practical Applications of the above Sciences, as well as of Students preparing for University and other Examinations. Two years of the Three Years' Course required for Graduation in Science at the University of Edinburgh may be taken at this College, and the Lectures in Chemistry and Botany are recognised by the Universities of Edinburgh and Glasgow as qualifying for the Medical Degrees of those Universities.

The extensive Laboratories (Physical, Chemical, and Biological) are fully equipped for Study and Research, and in the Physical Department special attention will be given to the Teaching of Electrical Engineering. A special course has been arranged in this subject. For Plans and Description of Physical and Chemical Laboratories, see *Nature* for February 26, 1885.

Laboratory Fees (per Term).

	Physical Laboratory	Chemical Laboratory	Biological Laboratory
Six Hours per week	£0 17 6	£1 1 0	£0 17 6
Twenty-four or more Hours per Week	2 15 0	4 4 0	2 15 0

Proportional Charges for more than Six or less than Twenty-four Hours per Week.

A considerable number of Scholarships and Exhibitions are open for Competition at the beginning of each Session, and several are awarded at the close of each Session on the result of the year's work.

For full Information see the College Calendar, which may be had (price 1s. 6d.) on application to the College Secretary.

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NOTES.

IN LIQUIDATION.—The firm of Oppermann Brothers is in liquidation.

NOTICE OF INTERRUPTION.—The cables of the Direct Spanish Telegraph Company are interrupted.

THE NEW TELPHER LINE.—The new Telpher line at Glynde, Sussex, is to be opened to-morrow (Saturday).

THE ANGLO-BRUSH COMPANY.—We are informed that Major-General C. E. Webber has joined the board of this company.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 9th inst. amounted to £3,121.

NEW CABLE STEAMER.—A new cable steamer, to be called the "Mirror," is being built for the Eastern Telegraph Company by Messrs. Napier, of Govan.

EARTHQUAKE IN SPAIN.—A telegram from Granada states that a strong shock of earthquake was felt there on Wednesday morning. No damage is reported.

GRUMBLERS!—The four American operators who went to Siam not long ago complain that they have nothing to do but draw their pay. Send that country right along here!

BOURNEMOUTH AGAIN.—We understand that the directors of the Shaftesbury Hall Company, Bournemouth, have been considering the desirability of lighting the hall with the electric light, but after a lengthened discussion they have decided in favour of gas.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 9th October, were £2,470, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

HARD LINES.—Female telegraph operators in Germany receive £48 a year, and no holidays. When one remembers the length of the words they manufacture in the Vaterland, one can have some idea of the drawbacks to the telegraphic profession in Germany.

A NEW POST OFFICE.—A large post and telegraph office has just been erected in Belfast. The telegraph instrument room is 101ft. by 52ft. and 35ft. in height, and every arrangement has apparently been made to ensure the comfort of the staff. The cost is estimated at £23,000.

ELECTRIC LIGHTING OF A TOWN IN SWEDEN.—It is said that the Thomson-Houston Company has received an order for electrical apparatus for lighting the entire city of Hermosand, Sweden. The city possesses a valuable water-power, which will be used for driving the dynamo machines.

TRUTH STRANGER THAN FICTION.—A writer in a gas contemporary at last admits, what we for long have stated, that "the electric light is at once the most formidable foe and the best friend of gas." The cry for more light is being heard, and is having its effect. The cry for a better and purer light will be followed by a like result.

THE ELECTRIC LIGHT IN GUATEMALA.—There are now about fifty lights burning in the city, the dynamo being run by a steam engine as a temporary arrangement until the turbines are ready for work. This department, together with the electrical apparatus at Zapote, is in the charge of an experienced mechanical engineer.

IN PERU.—The Peruvian electric lighting people are vigorously pushing their business in Peru, S.A., and expect to have all the business portion of Lima lighted by the latter part of next month. The electric company is in receipt of information from a number of Peruvian cities stating that as soon as the Lima plant is in operation orders will be forwarded for complete electric lighting plants.

A SON OF SCIENCE.—It is with great pleasure that we are able to chronicle an interesting event. On Wednesday morning at Broomhill, Tunbridge Wells, and under the electric light, a son and heir was born to Sir David Salomons, who is well known in connection with the electrical branch of science. If the son inherits the tastes of the father, he could not well have had an earlier introduction to electricity.

THE COREAN TELEGRAPHS.—It is said that different lines of telegraphs are to be constructed in Corea under the superintendence of Chinese officials. The preliminary surveys were commenced some little time ago between Gensan and Seoul, and at various points on the Chino-Corean frontier. The length of the lines actually undertaken is over 400 miles.

A PERMANGANATE OF POTASH CELL.—A modification of the Leclanché, called Roberts's permanganate battery, has been brought before the public. The solution consists of permanganate of potash, bichromate of potash, table salt, and sal-ammoniac. The *Electrical World* seems to think that this battery will burn solution and not zinc. If so, we will buy a few in anticipation of the millennium. The E.M.F. is given at 1·8 volt, and the internal resistance at ·7 ohm.

A LUCKY FLUKE.—It is said that Lilian Norton, the well known singer, was married about sixteen months ago to Mr. Frederick A. Gower, who lost his life recently. A few months ago she petitioned the Court for a divorce from her husband. A few days before the trial Gower's counsel secured a postponement of the trial so that he could go to Paris. Soon after his arrival there he accepted the invitation of a friend to make a balloon ascent, with the melancholy result with which we are familiar. Mrs. Gower has now gone to Paris to claim his estate, which is large.

A NEW PRIMARY BATTERY.—We are informed that Messrs. Woodhouse and Rawson have in hand, and are about to bring out, a new primary battery for domestic electric lighting, of which great things are expected. As, however, we have not yet had facilities offered us for inspecting the invention, we can say nothing as to its merits. Descriptions of it which appear in print are apparently on mere hearsay testimony, as it has, we have reason to believe, not yet been examined or tested by any independent authority.

INTERCOLONIAL CABLEGRAMS.—With regard to the negotiations between the Australasian Governments relating to a reduction in the telephone rates, a reply has recently been received to the effect that the New Zealand Government were ready to comply with the request, providing that the Government of Victoria would contribute a share of the cable subsidy. To this proposal the Victorian Government had replied, expressing their willingness to furnish a quota of the subsidy if New Zealand would do likewise with regard to the Tasmanian cable.

THE OVERHEAD WIRES AT WATFORD.—The Watford Local Board at any rate do not seem to be in love with overhead wires. At their last monthly meeting the clerk read a paper respecting an application which had been made for permission to erect posts in the district of the Board to connect Bushey Hall with the Post Office by telegraph. It was suggested, however, that the Board should not allow any more posts to be set up. The chairman said they did not want electrical wires; they were a horrible nuisance wherever they

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were. The matter was subsequently referred to the Highway Committee for investigation.

THE CHANNEL FLEET.—During the stay of the Channel Fleet in Stornaway Bay quite a sensation was caused by a display of the electric light from one of the ships. Although the night was dark, the brilliancy of the light showed everything quite distinctly, not only in town, but for miles around. The Fleet lay at Kirkwall all day on the 9th inst., and was visited by large numbers of people. In the forenoon the men of the "Iron Duke" engaged in gun drill. In the evening the "Minotaur" and two other vessels were lighted by electric light.

THE PROPOSED INTERNATIONAL EXHIBITION AT LIVERPOOL.—The proposed Exhibition of Navigation, Travelling, Commerce, and Manufacture, to be held in Liverpool next year, will, it has been decided, receive a large installation of the electric light. The grounds also will be illuminated by electricity, and there will be a fountain display, &c. Considering the dense population of Liverpool and the district within fifty miles—estimated to be larger than that of London and a radius of the same extent—the number attending the Exhibition is expected to be very large. It is intended to open the Exhibition about the middle of May next, and to close it at the expiration of six months.

THE TELEPHONE AT CHISWICK.—At an ordinary meeting of the Chiswick Local Board, held recently, the United Telephone Company asked permission to erect three ground poles on the north west side of Little Sutton-lane, bordering on Chiswick Park Club.—The chairman said the clerk and engineer to the company were in waiting to explain the proposed direction of the wires, and give any other information, and perhaps it would be better to call them into the room at once.—This suggestion was adopted, and the representatives of the company, having interviewed the Board, were told that their proposals would be practically agreed to, it being understood that a public call room would be made in or near the Vestry Hall.

ELECTRIC LIGHTING AT THE LEICESTER EXHIBITION OF THE SANITARY INSTITUTE OF GREAT BRITAIN.—The main hall of the Health Exhibition Building at Leicester is brilliantly lighted by five arc lamps of 4,000 candle-power each, arranged in a row down the centre of the hall; in the annexe are two more of these lights, and another is placed outside the building. The arc lamps used are the Crompton-Crabbe. The incandescent lamps are run off an Elwell-Parker machine, and are 40 in number, of the Woodhouse and Rawson type, this firm having put down the installation. One of Messrs. Marshall and Sons' portable engines, of 12 nominal horse-power, and fitted with Hartnell's patent automatic expansion gear, drives the lamps with perfect steadiness.

PRECAUTION.—An amusing story is told by the Milan journal *Pungolo*. It appears that a merchant of Turin who had correspondence in the French Department of Bouches du Rhone, received at his private house at Pinerolo a telegram from Marseilles. Upon reading it he discovered to his great annoyance that it must have been delayed some twenty-four hours. He called upon the telegraph clerk to account for the delay, and the honest man at once confessed that the despatch had indeed lain for a day and a night in his office. He went on to explain that as it had come from a place where cholera is known to be raging, he had felt himself bound, in compliance with the regulations of the Italian sanitary authorities, to disinfect it by exposing it to the fumes of burning sulphur.

SOME AMERICAN ITEMS.—A test of electric headlights for the Northern Pacific Railroad was made at Brainerd, Minn., on Sept. 18, it is said with perfect success.—It is reported that the new electric railway of Toronto, using the system of the Vanderpoele Electric Manufacturing Company of Chicago, is a success.—Newark, O., has contracted for electric lighting.—The Edison Company are running about 165,000 incandescents altogether.—There are now about 3,000 electric lights in the city of Philadelphia, public and private, the larger portion of them being owned by four companies, the Brush, the United States, the Thomson-Houston, and the Excelsior.—The electric light is to be introduced in the Nulhegan Lumber Mills at North Stratford, Conn.—The Sun Electric Lighting Company has been organised, with head-quarters at Chicago.

THE TELEPHONE AND FIREDAMP.—According to a contemporary, the telephone is said to be capable of making known the presence of firedamp in the atmosphere of a mine. This is the outcome of an interesting discovery in the matter of weather prediction. It has been found—so at least says our contemporary—that when two iron rods are placed seven yards or eight yards apart, and connected by an insulated wire, in the circuit of which a telephone is placed, indications of an approaching thunderstorm may be heard twelve hours in advance. A low buzzing sound is first heard, which becomes more and more loud and distinct as the storm approaches. Every change in the atmosphere is distinguished by different sounds more or less intense. When applied as a firedamp indicator this apparatus reveals by altered sounds the change which has taken place in the atmosphere by the escape of firedamp into it from the strata of the broken mine.

"TANNERGRAMS" AT WEST HARTLEPOOL.—At a recent meeting of the West Hartlepool Commissioners the truism that man is a dissatisfied animal was once more put in evidence. The matter of "tannergrams" happening in the course of the meeting to crop up, one of the commissioners said that now they had got the sixpenny telegrams he thought they should approach the General Post Office with a view to getting branch telegraph offices—one if not two. His impression was that if they had one in Milton-street and the other at the Stranton Post Office, or somewhere in Belle Vue, they would be found of infinite service. He moved that the authorities be petitioned. Another member suggested that an office for the cemetery district be added. The motion was put to the meeting and carried. However desirable these new "tannergrams" in offices may be, it is difficult to see their utility in a cemetery. What they should have there, in order to keep up the unities, is a good Dead Letter Office.

IRON POLES.—An American contemporary says that a metallic telegraph pole has been adopted by the Canadian Government for its telegraph lines on the North-Western prairies. The pole is constructed of malleable galvanised iron, and is 1½in. in diameter at the top and 2½in. in diameter at the bottom, and weighs less than fifty pounds. The bottom of the pole is set into a claw-plate, upon which the earth is closely packed to a height of about 2ft. Then another plate is put into place around the pole, and the earth packed upon it to the level of the ground. The claw-plates take a hold in the ground at once, so that the pole becomes solidly fixed immediately after being set, which desideratum is only obtained by the ordinary wooden pole after it has been in the ground for at least a year. A recent test is said to have shown the great strength of the pole, as a heavy No. 6 Government wire was strung and the poles subjected to the

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greatest possible strain, but without moving them in the least.

THE LIGHTING OF MINES.—The following is one of the clauses of the "Suggested Reforms in Coal Mining," submitted by Mr. Ellis Lever, of Manchester, to the Parliamentary Committee of the Trades Union Congress, which held its annual meeting at Southport not long ago:—"The necessity of using safety lamps in all mines or seams which admit gas, in however small a quantity, has been on many occasions abundantly proved. Real safety lamps of the best type only should be used, and in no case should the working miner be obliged to provide or to clean the lamp he uses. This should be done exclusively at the cost of the colliery proprietor. Inferior and notoriously bad lamps should on no account be allowed in any mine. All lamps should be officially tested and stamped by a Government representative before being used. Upon the better lighting of mines depends largely the safety of the miner's life and limbs, and every assistance should be given to invention in the direction of the electric system of illumination."

LIGHTING OF A SAVINGS BANK.—We understand that the Maxim-Weston Company have just completed their contract with the Government for the lighting of the Post Office Savings Bank, Queen Victoria-street. The original contract was for three gas engines of 40 horse-power each (indicated) and 700 lamps. Finding, however, that the engines were capable of running a greater number of lamps than what was originally intended, an alteration has been made in the installation whereby the authorities will be able to run nearly double the number of lamps. The dynamos used are of the Weston shunt-wound type, similar to those used on board the "Gallia," at Messrs. Rally Brothers, Manchester; and a number of other places. The lamp is the new Weston wavy filament, and, according to recent tests, thirteen of these lamps can be run so as to give a good light with only one horse-power effective. We are further informed that arrangements are now being made, by taking in an adjacent basement, to enable the plant originally intended to be largely increased.

THE ELECTRIC LIGHT IN CHEMNITZ.—The installation of arc lamps at Chemnitz, Saxony, possesses some points of novelty. The arcs are of the differential type, and take from eight to nine amperes. When the full light is not wanted they hang inside six side lanterns covered with transparent red calico. To each of the six sides is hinged below a triangular piece of the same material, each of these pieces bearing on a curved hook a brass ball. These balls press the six pieces together by their weight and close the pyramidical space below the lantern under the upper case. If the lamp is to give its full light it is lowered, when, by its weight, it presses the triangular pyramidal sides apart and descends. When it is to be raised again the cylindrical top of the lamp comes first in contact with six bars, which are fastened to the apex of the sides of the pyramid and bent outward. The pyramid opens and allows the lamp to enter the lantern, whilst the bars slide over the lamp globe, which is of strong glass, bringing the pressure of the balls to bear against the lamp, and thus securing its ascent in the central line.

THE SWAN SAFETY LAMP.—This lamp consists of the lamp proper and a secondary battery. The weight of lamp and battery together is 6¾lb., the cylindrical case containing the cells measuring 8 by 4 inches. The light given, for twelve hours' use, is equal to half a standard candle; but, by reducing the time of lighting to eight hours, the current may be increased, and a light obtained equivalent to three-fourths of a standard candle. A single charge provides for a whole day. Mr. Swan holds that the electric lamp is absolutely safe. If it is neither so light nor so cheap as the ordinary lamp, it is in both respects at least practicable, and the working cost will probably not be more than that of the ordinary lamps. As regards weight, he is not without hope of being able to reduce it. It requires no air; and there are, unfortunately, times after an explosion of fire-damp when the air of a pit is so foul that no oil lamp will burn in it. With a Fleuss apparatus for breathing and the electric safety-lamp, the work of exploration, which can hardly be otherwise accomplished, may be carried on, and this, it is reasonable to hope, will be attended with the saving of life.

THE DEFENCES OF NEW ZEALAND.—The Government of New Zealand have evidently determined, now that they have taken up the question of defences, to place them on a satisfactory footing. It is intended to arm the various forts now erected and in course of erection with the Brennan controllable torpedo recently adopted by the Admiralty. All the necessary apparatus, in the shape of powerful stationary engines and plant for ejecting the torpedoes, has been ordered. In addition each harbour will be protected by an elaborate system of submarine mines. The electric light having been proved to be an indispensable adjunct to modern warfare, each fort will be furnished with a complete set of searching lamps and apparatus. Three sets of plant (two of which are of the most powerful class in existence) have been ordered from Messrs. R. E. Fletcher and Co., electrical engineers and contractors, of Dunedin, in addition to those lamps which that firm have already constructed and supplied to the Defence Department. These sets of plant will be similar in design and capacity to those in use on the "Colossus" and other ships of the British Navy. Mangin projectors will be used, and the two larger lamps will be actuated by "Victoria" dynamos of the Anglo-American Brush Corporation's make.

A NEW TELEGRAPH COMPANY.—A new company, entitled the West African Telegraph Company (Limited), was registered on the 29th ult., with a capital of £1,000,000, in £10 shares, to carry on the business of telegraphy in all branches and in all parts of the world, power being taken to use all known systems or any system which may hereafter be discovered; and to purchase or cause to be manufactured wires and cables of all kinds for telegraphs, telephones, or other purposes. The subscribers are:—Abraham Scott, 157, Leadenhall-street, merchant, 50 shares; John Miles, 32, Paternoster-row, publisher, 100; G. Henderson, 7, Mincing-lane, merchant, 50; Matthew Gray, Lessness Park, Abbey Wood, Kent, engineer, 100; Robert Kay Gray, C.E., 106, Cannon-street, 25; Neil Bannatyne, 15, Earl's Court-square, merchant, 50; Wm. James Tyler, 106, Cannon-street, secretary to a company, 25. The number of directors is not to be less than five nor more than nine; qualification, shares or stock of the nominal value of £500; the subscribers are to appoint the first; remuneration, £2,000 per annum, with an additional £500 for every complete 1 per cent. dividend or bonus in excess of 6 per cent. per annum. The company takes power to acquire and carry out Government, municipal, or other concessions, relating to telegraphs or otherwise.

BLOWING UP THE FLOOD ROCK.—On the 10th inst., at 11:15 a.m., the explosion of Flood Rock at the Hell Gate entrance to New York harbour, took place by means of an electric current from the shore of Long Island. Three hundred

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thousand pounds of dynamite and rackarock were used, the rock having been honeycombed with galleries wherein the explosives were placed. A Reuter's telegram, dated New York, October 10, 6:0 p.m., says :—The explosion took place at 11:13 a.m., and apparently has completely destroyed the rock. It is believed that as soon as the necessary dredging is done the greatest obstacle to navigation in the East River will be removed. The shores were crowded with the people who gathered to see the effect of the tremendous explosion. When it took place the water was violently agitated immediately near the rock, but only for a moment. An immense volume of water, with large fragments of stone and wood, rose to a height of 150 to 200ft., trembled aloft for a second, and then sank into the river. The shock was slightly felt on the shores, but a tremble was felt throughout the city and for miles away. No damage was done to the surrounding property. General Newton's little daughter, a young lady eleven years old, pressed the button which started the electric current and thereby caused the explosion.

Hair and Electricity.—Those of our readers whose interest in electric lighting has made it at times difficult for them to keep their hair on will appreciate the following :—At the annual meeting of the American Dermatological Association, at Greenwich, Conn., remarks were made by various doctors who gave their experiences in removing hair from the face by electricity. Quite a large and important business is done in this line, especially among ladies. The only remedy is to kill the root of each hair, which must be done separately, by means of an electrical needle and battery. Dr. Fox said: In the case of a young woman with a heavy beard, he had removed, by actual count, eight thousand hairs. This process had required two or three years. Since then it had been necessary to remove only a few dozen hairs. The president, Dr. Hardaway, had performed the operation of electrolysis for ten or twelve years, probably longer than any other member of the association. He used the irido-platinum needle, which had the advantage of being bent, and was not likely to pass through the follicle wall. The moment the follicle was entered, there was an escape of sebum. One case, that of a woman with a heavy black beard, had been entirely relieved. Electrolysis with a fine needle afforded a method of getting rid of freckles. The plan was to dot the surface covered by the freckle with the needle.

Gas Journals and the Electric Light.—Here is a specimen of the fair and impartial criticism we are accustomed to at the hands of our gas lighting contemporaries :—"Several interesting matters in connection with the electric lighting business came up for discussion at the recent meeting of the National Electric Light Association. Mr. Leggett, of Detroit, read a paper on the tower lighting system as used in that city. Of course the writer claimed that the scheme was a grand success. 'It produces,' he stated, 'an artificial moonlight effect; and walking or driving by night is possible without constant apprehensions as to obstacles ahead.' Continuing, he said: 'Detroit is a city of from 160,000 to 180,000 inhabitants. Its business section occupies about one square mile. Around this is a belt about one mile in width, forming the residence portion of the town. Formerly 3,782 gas and naphtha lamps were used; while large areas, amounting to two square miles, were not lighted at all.' The Brush Company are paid 95,000 dols. a year for lighting the city, using ninety towers for the purpose. Well, they ought to light the place thoroughly for this sum. The 3,782 gas-lamps, at 16 dols. each, would only come to 60,512 dols., a vast difference. Another gentleman, speaking of the incandescent electric light, said 'We have to-day an infant seven years old, which, I think, is going to strangle gas with one hand and petroleum with the other.' Gas men will doubtless be glad to know that we shall have a companion in misery." The remark anent the same number of gas lamps is refreshing. Does the writer mean to infer that the candle-power is also an equal quantity ?

The West African Cables.—An important addition to the network of telegraphs spread all over the globe is about to be made along the West Coast of Africa. A new and improved cable, constructed by the India Rubber, Gutta Percha, and Telegraph Works Company, under the superintendence of Mr. Gray and his sons R. K. and Matthew, is now on its way on board the company's telegraph ship "Silvertown" to the French settlement at Dakar, there to connect with the existing Spanish line from Cadiz, and to extend in the first instance to Bissao, Bulama, and Conakry. From that it is intended to continue the line to St. Thomé, in the Gaboon country, to the mouth of the Congo, Loanda, Benguela, Walfisch Bay, and the north-western boundary of Cape Colony. So far the West African Company is acting on concessions from and in the interests of the French, and more especially of the Portuguese Government. As pioneer and tender to the "Silvertown," the "Buccaneer" goes out with Mr. J. Y. Buchanan, of the "Challenger" expedition, Mr. Rattray, naturalist, and Mr. Murray, who was also engaged in the "Challenger." Soundings and submarine testings, mechanical and chemical, will be taken of a range of ocean bed left unexplored by the great English expedition, and there can be little doubt that most interesting additions will be made to our knowledge of marine botany and zoology. There is happily no reason to dread the attacks of the microscopic-borer *teredo navalis*, whose partiality for dining off, or rather in, the gutta-percha coating of the wire sometimes sets free the electric current, and so destroys for a time work costing hundreds of thousands of pounds. *Teredo navalis* thus makes a meal the costliness of which dwarfs into insignificance that of the most luxurious banquets of Roman emperors.

Electricity and Ships' Compasses.—Commander Hudson calls attention, in a short article in the *Nautical Magazine*, to a possible action of electric light wires on ships' compasses. He thinks that while knowing the effect of the ironwork of the ship on the compasses, "we have an uncertain and unrecognised element of danger" in that the compasses, "placed in close proximity to the deck beams, will be liable to be acted upon by electric currents whose force and direction are continually changing as switches are turned on and off." The author gives in this article a ludicrous example of the incompetent electrical engineer, one, however, which might have caused considerable damage. Bad workmanship and ill-designed systems will prove a curse to the honest electrical engineer. The work on many ships is lamentable. In addition to the action on ships' compasses, there is another element of danger in the plan of connecting one wire from the dynamo with the ship's frame to earth. But here is Mr. Hudson's tale :—"The insulation of the feed wires in the saloon of a vessel fitted in this way being interrupted, to discover the position of the fault without unnecessarily taking down the linings, a temporary wire was led as a test wire from the dynamo in the engine room along the upper deck and down through the companion doors to the saloon. The saloon house was built of steel. Whilst the dynamo was running the saloon door accidentally closed, the insulating wire was cut through, and the wire coming in con-

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tact with the steel of the house formed a new circuit, the result being a flash of blue flame, the fusing of the wire, and the setting on fire of the board. Any one who had seen the utter look of astonishment and unpremeditated bolt on the part of the electrical engineer would have been quite convinced how little the danger attending a system of lighting in this manner was realised."

THE ELECTRIC LIGHT IN A LONDON CLUB.—As before mentioned in our columns, the Naval and Military Club, Piccadilly, has earned the distinction of being the first club in London with sufficient confidence in electricity to adopt it as its means of lighting. The engineers and contractors for the work are Messrs. B. Verity and Sons, of Covent Garden, London, who also have the contract, among others, for the lighting of the New Constitutional Club, Northumberland Avenue. Considerable difficulty was at first experienced in procuring suitable space for the electric machinery, but with the removal of some old stables in the rear a substantial engine house, with every requisite, has been erected by the contractors. Two steel multitubular boilers, with engines of the compound type, and fitted with automatic gear, have been specially manufactured by Messrs Davey, Paxman, and Co. The two substantial dynamos worked off the large fly-wheels have been manufactured in New York by Mr. Edison, at a special slow speed, for this club, and have come up with the high anticipation formed of them. Either of the engines or dynamos are sufficient for the whole present electric lighting of the club, and they are coupled up so as to give the most complete confidence. Added to this there are a set of 50 large accumulators, not only as a safeguard against any possible stoppage of the machinery, but also for supplying the light when the engines are not working. The lights are at present fixed throughout the whole of the club proper, and in some other departments—notably, the kitchens. In the principal rooms they are mostly fixed in elaborately etched and cut glass vases of Adams design, suspended from the ceiling, and cast a soft and well-diffused light round. The work of laying the wires has been a difficult one, owing to the character of the decoration and the necessity of the wires being completely hidden. Switches are provided for turning on and off the various rooms in sections, and the requirements of the insurances have been met by not only putting safety fuses on the one electrical pole of the wire, but on both positive and negative. All the wires are covered with no less than four separate coatings of insulation, and are protected by ornamental wood mouldings. The incandescent lamps used are of the Edison type. We hope that this important installation may soon be followed by many others of like character.

THE ELECTRIC LIGHT AND THE HASTINGS TOWN COUNCIL.—At a recent meeting of the Hastings Town Council the following report was taken as read :—The committee have had under consideration a renewed application from the secretary of the Hastings and St. Leonards Electric Lighting Company for permission to fix overhead wires for the supply of electricity between the company's works in Earl-street and Robertson-street. The committee have referred the matter for inquiry to a sub-committee, who have consulted with the electrician of the Eastbourne Electric Light Company, and have received from him a report containing the terms upon which he considered the application might be granted, with due regard to the public safety. This report has been submitted to the committee, and having fully considered the same, they recommend that the application be granted on the following conditions, viz. :—1. The wires used for crossing streets to have a tenacity of not less than 20 tons to the square inch, and weigh not more than 30lb. per 100 yards. 2. All main thoroughfares to be crossed at right angles, or as nearly so as circumstances will permit, and the wires to be shackled off on each side of the street, so that the space should be as short as possible. The supports, whether chimney stacks or poles, to be quite sound and well secured, and the wires run so that they cannot swing or rub against any angle of a wall, chimney stacks, &c., with any probable force or direction of the wind. 3. All wires crossing streets to be run at such a height as not to impede any fire escape in use, or likely to be used, in the borough. 4. All wires crossing streets or other public places, and their supports, to be examined periodically twice or thrice per annum, by some competent person on behalf of the Corporation, and the company to make any repairs or alterations which then, or at any other time, are necessary for public safety or to fulfil the above conditions. 5. The crossing places of streets to be settled by the borough surveyor or other competent person acting in conjunction with the Electric Light Company's engineer. 6. The company to undertake to stop the electric current in the event of a serious fire in a house supporting a wire or wires. 7. The periodical inspection of the wires to be at the expense of the company. 8. The wires to remain only during the pleasure of the council. 9. The posts for carrying the wires not to be put up in any public street without the express sanction of the council. Mr. Alderman Hennah rose to move the adoption of the report. He thought it would really be a good thing for the town to have these wires overhead, as, considering all restrictions put on the company in granting the privelege, the town would be in no way committed. The question would of course be raised about the danger, but he thought they had got over that by the shackling of the wires as suggested, and the condition of crossing the streets at right angles, so that in case of accident the wires would not come in contact with those down below. It had been suggested there would be some danger from the electric wire in cases of its breaking, but the electrician assured them that such was not the case, and that when a wire broke, unless they picked up both ends the current was broken, and there was no danger whatever. The question was also asked him (the electrician) whether, in case of an electrical storm, there would be any danger to the property to which the wires were attached, and the reply was that if there was the least danger of the kind it was not the property in contact with the wires, but to the machinery where the current was generated.—Mr. Weston begged to second the report. The committee which had been appointed to consider the matter had taken the opinion of a first-class electrician, and had then taken such precautions as they considered advisable for the safety of the public and the general interests of the town. In adopting that report, too, they would be assisting a public company, which had been struggling for some time to extend its operations by further lighting by electricity, which had been so satisfactorily done up to the present point.—Mr. Brown would like to ask the town clerk whether, in giving this sanction, they were likewise giving sanction to pass over houses and make fast to chimney-stacks of private property ?—The Mayor : You don't ask that seriously, do you, Mr. Brown ?—Mr. Brown : Yes, I do ; whether you have control over private property, or the streets alone ?—The Mayor : Certainly not.—Mr. Brown referred also to the 9th part, with reference to the putting up of posts in the streets only with the sanction of the Corporation, and said he hoped they would never give permission for the putting up of posts in Robertson-street, or any other streets for the carrying of wires, or any other purpose whatever. All he wanted was to know.—The report was then adopted.

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OLD CABLE STORIES RETOLD.—VII.

BY F. C WEBB.

(Continued from page 66.)

THE RED SEA AND INDIA CABLE OF 1859-60.

On the 14th February, on going ashore, we learnt that the Suakim-Aden section failed gradually until it broke down altogether on the 6th February, and as far as could be judged the fault was about half way on the section. Mr. Brunton and Mr. Forde came off to H.M.S. "Retribution" to ask for H.M.S. "Cyclops" to go up the Red Sea, and for the "Retribution" to take me to Muscat to test. "Cyclops" question was agreed to; but before "Retribution" question came on Mr. Newall arrived on board, and Mr. Brunton and Mr. Forde left.

On the 15th Mr. Brunton and Mr. Forde arranged with Mr. Newall to repair the Suakim and Aden section in the "Imperidor," which ship had still 400 miles of surplus cable left in her; Mr. Mayes, R.N., and Mr. Long were to go in her to watch proceedings. Mr. Brunton gave me a note, requesting me to hold myself in readiness to go to Hellania, the island of the Kooria Mooria group where the station existed, and to Muscat in H.M.S. "Cyclops," which ship he would apply for immediately.

During the ten days I was in Aden there were various festivities, in honour of the cable, on board the men-of-war (English and French), and the cable ships, and ashore at the military mess. On the 16th I see by my diary that there were races, of which, not being a horsey man, I have not the slightest remembrance. The officers of the "Cyclops" on this day dined with Mr. Long, the superintendent of the station. On the 17th the commodore gave a grand dinner to Mr. Newall, &c. I learnt that the Cosire and Suez section had also failed on Feb. 5 (two days before the Suakim and Aden section failed), but they had no idea where the fault was.

It is said that on the average it only rains once in five years at Aden, but when it does it is done thoroughly. The water accumulates on a plateau of table land, and pours down a ravine in the rocks. At the site of the tanks, especially constructed to collect the water, the ravine has been dammed up. Two ancient circular water tanks have also here been discovered and cleared of *débris* that had been washed into them. A heavy storm of rain, however, in May, 1859, brought such a flood of stone and water down that the new works were partly destroyed, and one of the ancient tanks was half filled up with stones. Five inches of rain fell in three hours.

On the 19th Mr. Newall gave a dinner on board the "Imperatrix;" the commodore and others went. I heard that Mr. Newall, in returning thanks when his health was toasted, asserted that "the cable would last for one hundred years!".

On the 23rd the "Imperidor" and "Imperatrix" left at 9 a.m. to repair the Aden-Suakim section. I tested this section roughly, and made the fault about 130 nautical miles from Aden. On the 24th I tested Aden-Kooria Mooria section. In the evening one of the cable ships spoke to Aden from off Perim. On the 25th I shifted from H.M.S. "Retribution" to H.M.S. "Cyclops" (6-gun paddle wheel corvette), Captain Pullen.

On the 26th I tried to get further tests of the Aden-Kooria Mooria section, but was stopped by a German gentleman, named Weyrich, because he said it would interfere with his testing the Aden-Suakim section. On the 27th I tried again to test, with the same result.

I went on board the "Cyclops" at noon, and at 7:30 p.m. we left for the Kooria Moorias with a small Indian navy schooner called the "Constance" in tow. The lieutenant in command of this small craft was said to be very eccentric, and one of his eccentricities nearly had rather serious results. He took it into his head one morning, when lying in harbour at Aden, to fire round shot at some seagulls on the beach, and nearly shot the Brigadier commanding at Aden, who was out for his morning walk, and was greatly astonished at a bang from the little schooner, and then by a round shot bounding along within a few inches of his legs.

Nothing particular occurred on our passage from Aden to Hellania, the principal island of the Kooria-Mooria group (where we arrived on March 4), except that we saw a large shoal of dolphins playing at leap-frog. Mr. Nichols was the local superintendent in charge of the station at Hellania, and Mr. Sannemans, from Messrs. Siemens and Halske, was in charge on the part of Messrs. Newall, Liddell and Gordon. I landed next day, and the "Cyclops" went off to Gibli, another island of the group, where there are guano deposits. I got my batteries and instruments ready at once. The "Constance," commanded by Lieutenant Cookson, I.N., was now anchored off the island for protection, but the marine artillery guard were still on the island.

Lieutenant Cookson came ashore and had tea with us, and I could see nothing in his manner to denote any eccentricity of character. On the 7th I tried to test, but was constantly stopped by Aden persisting in sending messages. On the 8th I again tried to test, but Mr. Long kept sending *long* messages, first to Hellania, then to Muscat, and then to Kurrachee. At last, in evening, I got a few tests of Aden-Hellania section. On the 9th I cut off Aden to enable me to use office batteries, and tested Hellania-Muscat section. At 3 p.m. joined up to Aden and asked them to let me have line at 7 p.m.; but at 7 they were transmitting to Kurrachee, and continued to do so until 9 p.m. Then Mr. Long sent a long message to me saying that they had been waiting for me at instrument since 7 p.m., and that it was not their fault, &c. The "Cyclops" arrived from Gibli this day, and was to sail the next day for Muscat. On the 10th, after some trouble, I got Aden to let me test. At noon Aden took line, saying they wanted it for one hour only. At 1:30 I called and wanted line, but Aden said they were in the middle of a Government message. I said I could not help it, I *must* have the line. Then there was a long argument between Long, De Conde, and I, and at last I got line and finished testing about 7 p.m., and about 10 p.m. got some test-message slips for proof of speed of working.

At 11 p.m. I took passage in the "Cyclops;" Mr. Sannemans also came, and the Marine Artillery Guard were also embarked, leaving the station to the care of Lieut. Cookson and the "Constance." I do not know whether he fired any more round shot at the shore, but the monotony of the situation would excuse even grape and canister. Commodore Edgell said that anyone who stopped there a year ought to have a pension of a £1,000 a year for the rest of his life. On the 11th, at 4 a.m., we started for Muscat, where we arrived on the 15th. I went ashore at 9 a.m., and tested Muscat to Hellania section. Mr. M'Gill was in charge for the company, and Mr. Buffleb of Messrs. Siemens and Halske, on the part of Newall, Liddell, and Gordon. On the 16th I made tests of Muscat-Kurrachee section, and at 10 p.m. started in the "Cyclops" for Kurrachee, Mr. Buffleb taking passage also in the ship. Arrived in Kurrachee on the 20th, when I began making test from the telegraph office at Manora Point of Kurrachee-Muscat section. I slept at office, and finished tests of section by half-past three p.m. I then wanted to get some tests right through to Aden, but, after a great deal of sending and squabbling, Muscat said that they could not get Hellania, so I had to give it up. On the 23rd I left for Bombay, and arrived there on the 26th, where I found my old friend the "Retribution." In the evening I went on board the Indian navy paddle-wheel frigate "Punjaub," then in full commission. This magnificent ship and her almost sister ship, the "Assaye," were sold in 1863 to Mr. John Willis, of London. The engines of both ships were taken out, and they were converted into sailing ships, the "Punjaub" being rechristened the "Tweed." Mr. Willis sold the "Assaye" to a Captain De Busch, and then (wonderful are the ways of Governments) the Government chartered both ships for laying the Persian Gulf cable. The "Tweed" was designed by Mr. Oliver Lang, of Woolwich Dockyard, at the time he was designing the present royal yacht, the "Victoria and Albert," and it was said that she had exactly the same lines as the royal yacht. She was built at Bombay Dockyard, of teak, with close timbers, like all wooden men-of-war, and was launched at night, as the night tides are a few inches

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higher than the day tides. She was one of the five sailing ships that took out the first Persian Gulf cable, the "Assaye" being another. The "Assaye" was lost on the west coast of Ireland on her way home, but the "Tweed" was one of the two ships that took out the second Persian Gulf cable. She gained the first prize at the Havre Maritime Exhibition, and is probably the finest sailing ship in the British merchant service, and the Parsee shipwrights of Bombay dockyard, who look upon her as their pet child, are justly proud of her. The brass in her engines fetched £5,000. When smoking a ciger on board her I little thought that I should have to cut her and the "Assaye" about in 1863, and be on board the "Assaye" in charge of cable laying in 1864 and fit the "Tweed" up again in 1868 for cable laying. I left Bombay for Aden in the "Ottawa" on the 27th March at 10 p.m., and arrived at Aden on April 4th at 10 a.m. I found that the "Imperidor" and the "Imperatrix" had been at Aden about the 29th of February, and had cut out seven miles of cable from the Suakim-Aden section, and laid it down again. On March 2 they had gone back to the other side of Perim, and had cut and found a fault near Suakim, and had gone there. During the time of their passage to Suakim Aden spoke to Suakim, and then the cable failed again.

When the vessels arrived at Suakim the staff were greatly astonished to find that Aden had been able to speak to Suakim, and would scarcely believe it. The "Imperatrix" had then left for Suez, where she embarked some of the Royal Artillery with Armstrong guns for China. The "Imperidor" went to work again, and had many difficulties, fell short of coals, returning to Aden on March 29 to coal; she left again on March 31. In the office at Aden they could not get Hellania up to the time I left in the "Ottawa" for Suez. This is all I can tell of the repairing operations, which I believe finally resulted in their inserting about 300 miles of new cable in the section. The line was for about a day workable from Kurrachee to Suez. It was one of the days between March 20 and March 23 inclusive, for a message from me at Kurrachee to my wife in London passed right through, and was one of the few messages that ever went through from India to England in 1860.

The testing appliances at the stations supplied by Messrs. Siemens and Halske were an immense step in advance of any previously used. The arrangement of the *Wheatstone bridge with high resistances* was a novelty to me, and I of course at once saw the great advantage thus offered to practical electricians, and, with the permission of Messrs. Siemens' staff, I availed myself of these instruments to take my tests, a few particulars of which I here append :—

RED SEA AND INDIA CABLE OF 1859-60.

	Nautical miles.
Weight of copper in lbs.	180
Gutta percha ditto	212

Tests of Aden-Hellania Section (taken by bridge), at Hellania, March 11, 1860.

	Nautical miles.
Length of cable	730
Distance by chart	717
Slack =	13, or 1·8 %.

Copper resistance in Siemens' units :

Z to E	4480
C to E	10160
2 /	14640
/	7320

or $\frac{7320}{730}$ = 10·03 Siemens' units per nautical mile.

Insulation res. C to E	69900 S.U. absolute.
× Length	730 naut. miles.
	2097000
	489300
	51027000

or 51 million Siemens' units per knot, with 60 elements C to E.

Trying rate of working on Morse with Siemens' polarised relay got 28 words in four minutes from Aden,

$= \frac{28}{4}$, or 7 words per minute.

And, again, 19 words in three minutes,

$= \frac{19}{3}$ or, 6·3 words per minute.

Tests of Hellania-Muscat Section, taken at Muscat, March 15, 1860.

	Nautical miles.
Length of cable	493
Distance by chart	488
Slack =	5, or 0·1 %.

Copper resistance C to E 4172 Siemens' units.

$\frac{4172}{493}$ = 8·5 Siemens' units per nautical mile.

Insulation resistance C to E	129000 S.U. absolute.
× Length	493 naut. mile. 2
	387000
	1161000
	516000
	63597000

or 63·6 million of Siemens' units per nautical mile.

Test of Muscat-Kurrachee Section, taken at Manora Point, March 20 and 21, 1860.

Length of cable	490
Distance by chart	477·5
Slack =	12·5 or 2·5 %.

Copper resistance C to E 3967 Siemens' units.

$\frac{3967}{490}$ = 8·01 Siemens' units per nautical mile.

Insulation resistance C to E	170000 S. U. absolute.
× Length	490 naut. miles.
	15300000
	680000
	73300000

or 73 million Siemens' units per nautical mile.

We should think very little of a line in these days which only gave 70 meg. per nautical mile.

With regard to the machinery and tanks, &c., I cannot speak, as I did not go on board either cable ship. I have, however, a large and complete drawing of the brake employed, given me by Mr. Newall; but it would be impossible to describe it in writing alone. I shall some day, I hope, exhibit it, with many others of machinery I have used, at a lecture on the subject of cable engineering. The cable was never repaired in all its sections, and some years later a quantity of the cable was recovered in the "Sir James Duke," under the superintendence of Mr. L. Clark, assisted by the late Mr. J. C. Laws.

The cruise, by what I gathered from the staff on its return, was not a pleasant one as regards personal comfort, the accommodation being simply execrable. Major Green, at Muscat, I have heard, said that he would sooner go into general action than live one week on board the ship. The discomfort was, however, borne with great good humour and patience by the staff, three of whom have since died, viz., Mr. J. C. Laws, Mr. Alexander, and Mr. Suter. The latter, who was my assistant in the "Old Monarch," died during the expedition at Aden, and is buried there.

Some of the cable was recovered, and the "Sir James Duke" had her screw taken out at Aden, and sailed for England, the late Mr. Alexander being on board. She took a fabulous time to get home, and stuck about the Cape for several months, hundreds of ships passing her. Like a second "Flying Dutchman,"

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the captain "tried in vain his oath to keep" to get home in three months. Mr. Alexander gave me an account of the voyage home. After the first month they had nothing but salt provisions—except some very long-legged, bony fowls—and the captain had but one story, which he began regularly to tell after his first *post-prandium* glass of grog, till poor Alexander got so sick of it that he would bluntly interrupt the captain at the very first word by a "Suppose we go on deck, Captain." On arriving off Falmouth Mr. Alexander went ashore in the pilot boat, rushed to an hotel, and ordered supper. The waiter brought in *a fowl*, which so incensed my poor friend that he hove it at the astonished waiter's head, and then ordered baked potatoes and champagne; and this was about the last incident connected with the Red Sea and India cable of 1859-60.—*R.I.P.*

HISTORY OF THE INCANDESCENT LAMP.—III.*

Twenty years ago Swan commenced to experiment with carbon filaments in exhausted globes, but for want of an economical means of producing the current and a good vacuum such experiments necessarily led to nothing practical. The experiments were resumed in 1877, when the dynamo had opened an entirely new field. The discovery of the Sprengel pump gave a ready means of obtaining a far more perfect vacuum.

Swan had the good fortune to make the acquaintance of Mr. Stearn, who had already attained to a place among the first authorities on the question of high vacua.

All the various attempts towards the practical application of the carbon-incandescent principle had two great obstacles to contend with, which baffled every exertion made to overcome them. One difficulty consisted in the rapid wear and consequent breakage of the carbon; the other in the obscuration of the lamp by a sort of soot. These two phenomena appeared with such a uniform consistency that the opinion was soon formed that the blackening of the glass bulb was the result of the volatilisation of the carbon under the influence of enormous heat.

Swan fortunately attached no great significance to these experiments. He knew, in fact, that the conditions under which all the earlier experiments had been made were not such as to render possible the attainment of an even approximately perfect vacuum. Swan saw perfectly well that the first thing to be done was an experiment to raise the carbon to a white heat in a perfect vacuum, and under conditions more favourable than before. In furtherance of this idea he in 1877 sent Mr. Stearn a number of pieces of carbon made from carbonised cardboard, requesting him to have them mounted in a glass bulb, to be then exhausted as perfectly as possible. Mr. Stearn undertook this difficult operation with the greatest willingness, and carried it out with singular skill. Mr. Stearn described this experiment as follows in an article kindly placed at the disposal of the writer:—

"The first result of our combined labours was obtained on the 3rd November, 1877. A strip of carbonised paper was fixed between the platinum wires (as shown in Fig. 1), the

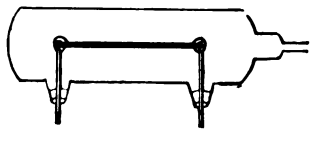

Fig 1.

opposite ends of which were passed through the side of the glass and sealed into it. The resistance of the carbon was so great that twenty Bunsen cells were required to raise it to a red heat. This first experiment failed, as the carbon at the first passage of the current was broken with the momentary strain when the carbon was exposed to a higher temperature than that employed in carbonising it.

"This risk was avoided in the next experiment by stretching the carbon filament less tightly between the conducting wires. In the next attempt with carbonised paper small pieces of platinum foil were connected with the carbon strips by means of electrolytically deposited copper, as shown in Fig. 2.

Fig. 2.

"The lamp shown in Fig. 3 was now constructed. This consisted of a thin carbon stick of circular section, in platinum holders, which were connected with the platinum wires passing through the glass. The latter was sealed up after a long exhaustion by means of a Sprengel pump. During the years

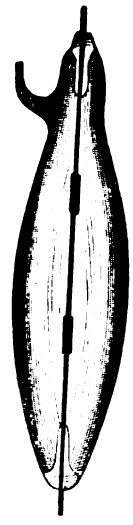

Fig. 3.

1878 and 1879 we made experiments with these and other forms of carbons, and the result was patented in England on the 2nd of January, 1880 (Swan's patent 2nd January, 1880).

"A lamp of the kind shown in Fig. 4 was exhibited at a meeting of the Newcastle-on-Tyne Chemical Society, on the 18th of December, 1878, and the same subject was also discussed on the 27th of March at a meeting of the same Society (vide *Chemical News* of April 18th, 1879, and June 27th, 1879). On the 3rd of February, 1879, and on the 12th of March of the same year, this lamp was exhibited in action at numerously attended lectures delivered by Mr. Stearn in Newcastle

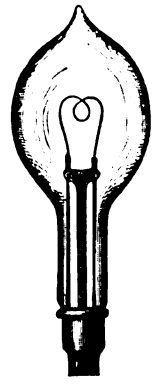

Fig. 4

and Gateshead, the chair being taken by Sir William Armstrong. These lamps were composed of nothing but glass, platinum, and carbon, and were hermetically sealed after the most perfect exhaustion with a Sprengel air pump."

One of the most important problems was the question how to free the carbon conductor during the process of exhaustion from the noxious gases contained in it. "Edison," Mr. Stearn goes on to say, "thought that he could claim for himself alone the credit of having achieved this object (*vide* English Patent, No. 562, Feb. 9, 1881). But it must be remembered that as

* Abstract of an article by Prof. Dr. Rudolf Lewandowski in *Zeitschrift für Elektrotechnik*.

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early as 1878 other experimenters recognised the necessity of purifying the carbon from the gases contained in it, although, instead of gases rich in oxygen, they passed in a gas neutral in oxidising properties. Sawyer and Mann (Cheeseborough Patent, Nov. 28, 1878) employed a method by which the carbon was heated by the current, and then allowed to cool in an atmosphere of nitrogen. Sawyer and Mann introduced at the same time another most important improvement in the construction of the incandescent lamp, described in the above-mentioned patent. This was a process to give strength and uniformity to their slender conductors by filling up their inequalities and irregularities by the deposition of carbon obtained by electrically heating them in a bath of liquid or gaseous hydro-carbon.

It is now admitted that Sawyer and Mann were answerable for these improvements.

Lane-Fox in his patent enunciates the principle, already established by King, that the dimensions of the conductor must vary according to circumstances, in the following

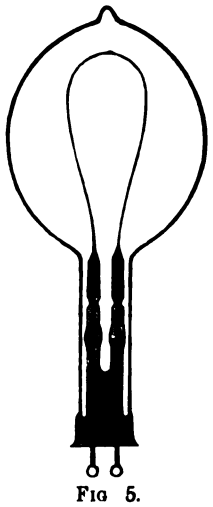

Fig 5.

words :—"The length and thickness of the spiral depends on the intensity of light required and the electromotive force to to be employed."

We have here certainly something definitely stated as to the dimensions of the conductor; but it is a fact, as may be seen from the diagram (Fig. 5), that Lane-Fox in his incandescent lamp, patented in 1878, employed a carbon filament for his conductor, and that he has a share in the patenting of a carbon filament lamp. Lane-Fox worked almost contemporaneously with Mr. Swan on the application of carbon to incandescent lamps, and in another patent, No. 1,122, of the 20th March, 1879, he states the unavoidable necessity of using high resistances, where high electromotive is to be used for lights of low intensity.

We have thus seen that the fundamental principles of the present incandescent lamp were known as far back as 1845, but twenty years more elapsed before these principles were developed into the manufacture of the present type. It is indisputable that the first patent for an incandescent lamp of the form now generally adopted was taken out by Lane-Fox, in 1878. This patent, however, must not be referred to the principles laid down by Starr, which found expression in the patent taken out by King, but should be considered on its merits of more or less novel details of construction.

That Du Moncel's somewhat severe remarks were justifiable is clear to the most casual student of the history of the incandescent lamp. Events, too, have vindicated his predictions, for Edison's lamps, with carbon filaments of the kind already mentioned, quite failed to justify the hopes reposed in them. But such and similar disappointments were wholly unable to discourage the eager genius of Edison, and only spurred him on to new achievements. On the 16th September, 1880, two months after the patenting of Swan's lamp, with its filament of specially prepared cotton, he took out a patent for the materials used in the present Edison lamps. This consisted of thin bamboo strips of the well-known shape shown in Fig. 6.

The success of Swan and Edison stimulated other workers in electricity towards the construction of carbon incandescent lamps. Maxim, Lane-Fox, Müller-Northomb, Puley, Burnstein, Woodhouse and Rawson, Gatehouse, and most recently Herr M. Von Bernd followed one another in a tolerably consecutive series, their lamps being all in essential principles comparable to those of Swan and Stearn and Edison, these principles having become recognised for the last ten years as alone suitable for the purpose, the distinctive characteristics of the various types being confined to degree of finish in construction, shape of bulb and material, shape and thickness of carbon filament. We may cite as an interesting fact that a few months ago a young electrician, Herr Max Von Bernd, of Wiener-Neustadt, has succeeded in replacing broken filaments by a very simple process, and thus repairing worn-out lamps, a discovery promising to be of great value in reference to the cost of maintenance of the incandescent lamps.

Thus, thanks to the laboriously accumulated experience of these indefatigable workers, has the science of electric illumi-

Fig. 6.

nation achieved a consummation which will open out a way for it to the palace and the cottage, and insure an increasing field for its universal application.

LITERATURE.

Arithmetical Physics. Part II. B. Magnetism and Electricity. By C. J. Woodward, B.Sc. Simkin, Marshall and Co.

We have had occasion to refer to previous works of this series as being written with a special object. This object is to assist students in preparing for examination. Although we hold, with Prof. Crystal, that the present examination mania is more of a curse than a blessing, and that books written for examination purposes are not equal in value to those written for educational purposes, we are bound to admit that most of these books serve a useful purpose. A student may have, and frequently has, a fair grasp of principles, yet be utterly unable to apply the principles, or to investigate their application by rigid mathematical scrutiny. The man who can only vaguely generalise is almost worthless. Qualitative analysis in electrical matters must be accompanied by quantitative measurements to be of practical use. Such books as this of Mr. Woodward are admirably adapted to initiate the student into the mysteries of quantitative work.

Errata.—In Sir W. Thomson's article on "Multiplying Potential" in our last issue, in the fifth line of text, for "n and the" *read* "$n+1$;" and in the eighth line, after the word successively, *insert* "and at short intervals of time."

Brazilian Submarine Telegraph Co.—The Directors of this Company will, at the general meeting on the 29th inst., recommend a final dividend of 3s. per share, payable on 30th inst., making 6 per cent. per annum for the year ended 30th June. £12,000 has been placed to reserve.

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All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE COMPOUND WINDING DISPUTE.

Although it would be improper and impertinent to offer here any opinion upon the legal aspects of this latest conflict among electric lighting patents, the facts of the case are of sufficient interest to be set forth in due order, and the consequences of legal action in the matter are of such serious moment that we do not hesitate to express our opinion as to the inexpediency of resorting to that mode of settlement. It is a costly process at best, and as we had occasion to observe in regard to electric lamps, it can only end in unsettling proprietary rights in general without establishing anybody's in particular. When the dogs are called in to arbitrate between foxes over a contraband goose, whatever becomes of the bird, the vulpines are safe to lose it. And this, we think, without meaning offence to electric lighting engineers, will be their case if they try to affirm with legal precision claims which would very well stand on their own practical merits, but which if too nicely inquired into may prove to be out of date and wholly untenable. The goose may be mauled almost past recognition, but if she is of proved maturity and species known, her rightful place in the farmer's yard can hardly be gainsaid. A number of electrical discoveries have been for many years straying about the common land, unused and almost forgotten. Suddenly their utility is perceived, and after much ingenious pains bestowed on them they are turned to practical account. No wonder that ownership is vehemently asserted by all and sundry who have done anything towards converting a barren theory into a serviceable reality; and no blame to them. But under the circumstances prudence would dictate that there be as little squabbling about the prey as possible, lest the true owner—but we need not finish the sentence.

So far as we can gather, the present dispute arises out of an assertion on the part of the Brush Company that they invented and patented, several years ago, the principle of compound winding for dynamos. It occurred in a patent of numerous claims, where it was suggested for electro-plating purposes. Meanwhile somebody else had worked out, by hard experience and costly experiment, that the principle was good for dynamos for electric lighting; and, adapted in a certain manner, machines of great power and popularity have, for three or four years past, been constructed on this principle, covered of course by patent. It then naturally occurs to the Brush patentee that something, too, could be made of the similar principles embodied in his miscellaneous patent; and in due accordance with Patent Law all the rest of the patent is disclaimed, and this alone let stand. It had never been used apparently; but by virtue of elimination it now becomes a valid independent invention, and the makers of compound-wound dynamos are forthwith warned that they will be infringing this patent if they make any more. This is curious; but everything is curious where Patent Law comes in. Patent right has sometimes been described as a patent wrong backed by a right lump of money; and we have little doubt that if the latter is forthcoming, tempered by no second thoughts as to consequences, the right, such as it is, will be upheld. But the question at once occurs to us—What would it be worth when established?

Let us consider this point with candour and impartiality. We are not sure that a "principle" can be patented—a theory cannot, unless it has a practical application—and in the case we are considering the application was to a purpose quite different from that to which it is now diverted, to the exclusion of other people who had already applied it to that special purpose. But if a principle can be patented apart from its special application, then it is certain that this principle of compound winding has been patented more than once before, and used in numerous ways. We need not particularise; the fact of its early use, for example, in telegraphy is well known, and the archives of the Patent Office show beyond question that the principle and its applications were matters of patent right long before the Brush "Teazer" was thought of. It does not, of course, follow from this that the Teazer patent has no independent validity; we are not laying down the law; what, however, may be fairly doubted is the possibility of legally widening the scope of this particular device to the exclusion of all its rivals. And we should be inclined to say the same thing of all modern dynamo patents.

These facts tell, of course, with equal force against the patentees of compound winding applied to electric lighting dynamos. Probably they would acknowledge this if their rights, such as they are, were not threatened by patentees whose ideas were certainly behindhand in taking practical shape. As against the original discoverer or discoverers, whoever they may have been, we hold that the claims of all these later rivals are invalid, because their principle was forestalled. Compound winding was long ago used avowedly for the purpose of controlling, regulating, and sustaining a current. As to the application of this method to the requirements of Electric Lighting, if that and that alone is the point now in dispute, it can only be determined in one way, namely, by the test of date; and the Brush claim will hardly stand this test, we fancy. In short, the theory,

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being old, belongs in the commercial sense to nobody; the practice, being new, belongs, if to anybody, to the first comer. That the idea was suggested, or even utilised, for electro-plating eight years ago has as little relevance as the fact that it was suggested and used for other purposes eighteen years ago. If ideas count for anything, the earliest bars the later; and so with deeds. It is hardly likely, therefore, that the first makers of compound-wound dynamos will abandon their work without a struggle, simply because somebody else had patented an idea which might have been turned to the same account, but was not. If, however, it comes to challenging rights, we gravely doubt whether any exist worth speaking about; and we should advise all parties alike to refrain from proceedings which can establish nothing and may probably disturb a great deal.

CORRESPONDENCE.

A PHENOMENON OF CURRENT INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I feel myself happy in having obtained a word from Mr. Sprague on this subject. Nevertheless, I confess I am a little puzzled by his letter in your issue this week (Oct. 9). Your correspondent, if I rightly understand him, refers the phenomenon in question to certain considerations connected with the direct currents of induction and the prolongation of magnetism in the core which results from their influence. The action of these currents had not escaped my consideration, but they seemed to afford no explanation of the phenomena. May I ask Mr. Sprague to be good enough to be a little more explicit, and to state for my benefit (1) whether he considers that the prolongation of the magnetism in the core is greater or less when the secondary circuit is closed? Unless he replies that it is *less*, he would afford no explanation of what actually occurs. Meanwhile he has pointed out that the direct currents of induction, to whose influence the prolongation is due, are developed partly in the primary wire and partly in the secondary wire, and I still follow him where he says that the ratio of these two developments of current is "according to" (*lege pro* amounting to?) "the resistance of the secondary circuit." Thus I gather that as long as the resistance of the secondary circuit remains *quasi*-infinite owing to the disconnection of its terminals, the induction will be confined to the primary wire; also that as soon as the secondary circuit is completed it becomes, in its own measure, an available channel for induced currents. Would Mr. Sprague kindly state (2) whether from his point of view this change of relations will lead to greater or less influence upon the core, tending to retard its demagnetisation?

I quite follow your correspondent in the general principles which he enunciates, but I should be glad to learn how he considers these principles are applicable as an explanation of the phenomenon that the spring vibrates faster when the secondary circuit is closed.—Yours, &c.,

Oct. 10th, 1885. E. ALDRED WILLIAMS.

LIFE OF INCANDESCENT LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think if some of your correspondents on this subject would state what they find to be the life of their lamps, your readers could find the average themselves.

For this purpose I beg to enclose small table, showing what I have found to be the life of the lamps of five different makers, all of which gave way during the past nine months. A dated label was put on each lamp when it was put into the circuit, and as a note is kept of hours lit each night, the life of these lamps was easily ascertained. They are all 50-volt lamps, and were in the same circuit, but were not all put up at the same time. The latter may account for some lasting much longer than others, as the remainder of those in columns 3, 4, and 5 are still burning.—Yours, &c., ENQUIRER.

Edinburgh, 10th October, 1885.

NOTE.—The numbers refer to the various makers:—

Nos. 1.	2.	3.	4.	5.
2,600.....	900.....	350.....	1,300.....	70
2,000.....	80.....	1,300.....	1,550.....	500
360.....	1,800.....	290.....	—	80
2,700.....	1,800.....	—	—	—
2,250.....	1,600.....	—	—	—

DIFFERENCES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As a constant subscriber to your journal since its commencement, I regret to see letters appearing in its columns with the apparent object of advertising the writers, and otherwise void of information.

In your issue of the 9th inst. I find a letter, signed "Alfred J. Thompson," referring to *rockets* being used for passing wires over forbidden ground. This gentleman, after asserting that a Mr. Danvers has made a mistake in claiming the novel use of rockets for passing wires as his own idea, proceeds to mention that he has used "bow and arrow, slug sling," &c., as a means for passing wires over forbidden grounds, &c.; and then winds up with the remarkable statement that *rockets* were too expensive an item.

Therefore, so far as Mr. Thompson is concerned, according to his own statement Mr. Danvers has the prior claim.

Perhaps it will astonish Mr. Thompson to hear that "rockets," to my own knowledge, have been frequently used for the same purpose years before the telephone was thought of as being of commercial value.

Apologising for taking up space in your valuable journal, Yours, &c., VERB. SAP.

October 13, 1885.

THE INTENSITY OF THE HORIZONTAL COMPONENT OF THE EARTH'S MAGNETIC FIELD.*

BY THOMAS GRAY, B.SC., F.R.S.E.

Abstract.

The general principle of the method adopted was that of Gauss, with these modifications. In the deflection experiment the magnetometer needle was made so short that in the calculations it could be assumed, without sensible error, to be of zero length, and two deflectors were used simultaneously. The deflectors were placed one on each side of the magnetometer needle, with their axis in a line at right angles to the magnetic meridian, and in position for deflecting the needle; the directions of the line passing through the centres of the deflectors and the magnetometer needle were, first, the magnetic meridian, and, second, a line at right angles to it. The author pointed out that this mode of procedure leads to two equations, which suffice for the determination of the horizontal component of the earth's magnetic field and also of the effective length of the deflector. In these equations he also showed that the length of the deflector entered as a minus term in the one and plus in the other, and thus rendered the observations highly sensitive to possible errors in that term, and enabled a good estimate of the effective length of the different deflectors to be had. Apparatus was described by which the whole cycle of observations, both for this and the oscillation experiments, might be obtained without the necessity of handling the deflector magnets.

The effects of the various corrections on the value of "H" derived from the equations were discussed. Such of the errors as were sensible had been made the subject of direct experi-

* "On Measurements of the Intensity of the Horizontal Component of the Earth's Magnetic Field, made in the Physical Laboratory of the University of Glasgow."

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1885.	No. of Deflector.	Approximate diameter of Deflector in cms.	Length of Deflector in cms.	Weight of Deflector in grammes.	*East & West Position.* Distance of centre of Deflector from magnetometer needle in cms.	*North & South Position.* Distance of centre of Deflector from magnetometer needle in cms.	Distance of the scale from the magnetometer needle.	Effective length of the Deflector.	Magnetic moment per gramme of the Deflector.	Horizontal intensity in C. G. S.	Mean of each set of results.
May 27	1	0·25	8·03	3·050	32·06	28·75	108·7	6·91	44·9	·1520	
,, 27	2	0·25	8·05	3·063	32·06	28·75	108·7	7·10	58·5	·1524	·1522
,, 28	3	0·25	8·05	3·075	32·06	28·75	108·7	6·31	54·1	·1521	
,, 29	4	0·25	8·05	3·067	32·06	28·75	108·7	7·11	52·3	·1522	
June 5	5	0·25	4·00	1·526	30·0	25·125	108·7	3·12	35·2	·1524	
,, 5	6	0·25	3·99	1·522	30·0	25·125	108·7	3·72(?)	33·7	·1524	·1525
,, 5	7	0·25	4·00	1·525	30·0	25·125	108·7	2·33	31·7	·1527	
,, 10	8	0·25	14·933	5·646	51·9	38·85	108·7	13·22	55·8	·1527	
,, 11	9	0·25	15·030	5·727	51·9	38·85	108·7	12·82	64·3	·1525	·1525
,, 11	10	0·25	15·021	5·666	51·9	38·85	108·7	13·58	54·5	·1527	
July 21	11	0·20	10·01	2·318	35·0	30·0	128·9	9·14	71·0	·1526	
,, 21	12	0·20	10·01	2·336	35·0	30·0	128·9	9·14	62·7		
,, 26	11	0·20	10·01	2·318	35·0	30·0	128·9	8·98	71·0	·1527	·1526*
,, 26	12	0·20	10·01	2·336	35·0	30·0	128·9	8·98	62·7		
,, 31	13	0·20	10·00	2·318	35·0	30·0	128·9	9·14	70·0	·1526	
,, 31	14	0·20	10·005	2·336	35·0	30·0	128·9	9·14	61·8		

* Corrected to noon for diurnal variation.

ment, and their effect allowed for in the table of values of "H" given in the paper and quoted above.

As the observations necessary for a determination of "H" by this method extend over such a time as may make the diurnal variation sensible, and further to guard against the readings being vitiated by undetected magnetic storms, a magnetic vibrator was kept going throughout the time of the experiment and its period taken from time to time as might be found necessary.

REMARKABLE OCCURRENCE DURING THE THUNDER-STORM OF AUGUST 6th LAST AT ALBRIGHTON.*

BY J. BEDFORD ELWELL.

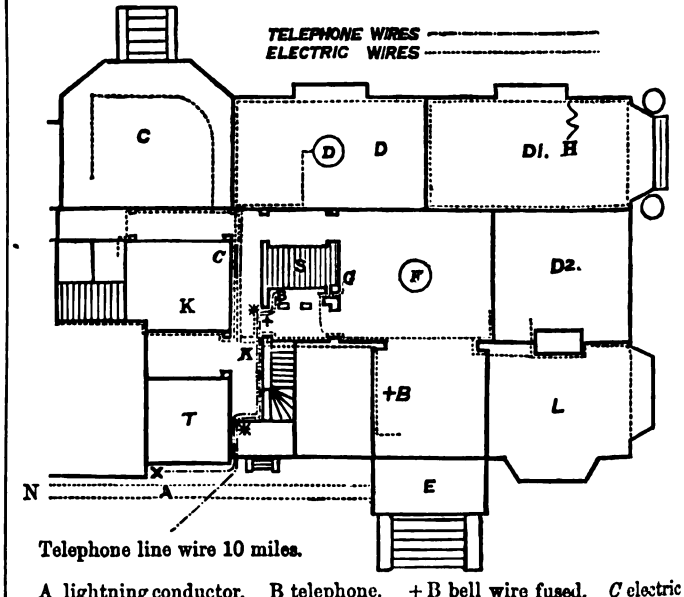
St. Cuthbert's, my residence, is situated at Albrighton, ten miles from Wolverhampton, with which it is connected by telephone. The house has a lightning protector twenty-five years old. The telephone wire very improperly makes earth on this conductor. The storm was at its height about half-past eight in the evening, and we had just retired to the drawing room, there being only a single lamp left alight in the dining room, in the centre of the corona. The telephone bell was sounding with every flash of lightning, when suddenly a report like a rifle-shot was heard in the hall, and at the same instant the servants in the dining room were plunged into darkness by the lamp in the corona flashing up and then going out. (Another lamp was immediately put in, showing the leads were not injured.) Also at the same moment the telephone wires were both fused at points marked * by one of which the wire sometimes used to connect telephone with drawing room through the light switch-board, but not then connected with telephone, passed. This was also fused, and through it the lightning tried to make earth (or *vice versâ*) all over the electric light system, succeeding in one place, in a bed room over the entrance hall, where a bell pull was close to one of the leads. The current struck across, showing an E.M.F. of many thousand volts, and fused the bell wire. None of the lead cut-outs were fused on any of the wires.

On examining the burnt lamp in the dining room it was found to be so blackened that (although it was perfectly clear and bright the moment before, and being a 48-volt Swan lamp could not be overrun from 24 cells) it was with difficulty that the filament could be seen. It was burnt off at *both ends* where the platinum wire joined, *and lay entire* in the bottom of the globe. The glass globe has become a beautiful mirror, by the fine particles of platinum that have been projected against it. A few globules of melted glass or platinum were also rolling about within the globe. A *separate earth plate* has since been put to the telephone, so that nothing of the kind can again happen.

* Abstract of paper read at the Aberdeen Meeting of the British Association.

Details.

The telephone instrument B, in the recess of the main staircase, has both line and earth wire running side by side until both emerge from the house at the corner of the tower, where the earth wire is twisted round the lightning conductor + at A.



A lightning conductor. B telephone. +B bell wire fused. *C* electric light switch board. C conservatory. D dining room. (D) corona over dining table where lamp was blackened. D1 and D2 drawing rooms. E entrance. (F) electrolier in hall. G single lamp in hall alight at the time and not affected. H lamp alight and not affected. K K lamps alight and not affected. L library. N naked wires, on insulators, from engine house to accumulators in a cellar below entrance hall. S staircase. T tower carrying lightning conductor. X telephone earth. N.B.—The corona in dining room is lighted from an upstairs lead, which also feeds four bed rooms in which no lamps were alight at the time.

The lightning conductor, erected 25 years ago, is a copper cable ⅜in. diameter, and about 60ft. long—the tower being about that height—insulated from the building, with the earth end simply buried in gravel, but in a spot where the soil is nearly always moist at the surface (after the storm, the conductor was tested with an ordinary detector galvanometer, and showed a good earth).

The electric light—supplied entirely from Planté-Parker accumulators, 24 in series, placed in a cellar below the entrance hall (in use for nearly three years past without a plate being

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renewed, or showing any signs of requiring renewal)—is used all over the house, including nurseries, kitchens, and cellars; and the leads, eight in number, all start from the switch-board at C, behind the main staircase, each having its main fuse at the switch-board.

Theatre Wire.—This is a small wire (22 G) running from the telephone at B (but not connected with it at the time) by the side of the telephone wires as far as K, then turning off to the switch-board, where it communicates with the light leads, which are thus used occasionally for the double purpose of lighting and transmitting operatic music from the theatre at Wolverhampton to some of Tayler Smith's connections in the drawing room, to which a telephone receiver may be attached at will, the earth being obtained through the drawing room window (26 G bare wire). The turning on and off of lamps does not affect the telephone.

The above are all the points connected with the matter.

ELECTRIC CONDUCTIVITY OF METALS AND THEIR ALLOYS.*

BY M. LAZARE WEILER.

In the study of all electrical problems, and especially of such as relate to dynamic electricity and its applications, we are brought at the outset to the consideration of conduction. Whether it be a question of light, of force, of heat, of chemical or mechanical phenomena, or, in a word, of any transformation whatever of electricity, it is indispensable to know the quantity of electricity produced at the source, and the amount afforded at the place where it is utilised. The nature of the intervening conductor becomes then one of the principal elements of the problem. In the dynamo-electric machine, which is only a conductor or a series of conductors subjected to magnetic induction, the property of conductivity is an important one. The properties, therefore, of different metals and their alloys, as regards their power of transmitting electricity, afford a subject of exceeding interest.

This question furthermore merits our attention now, for the reason that physicists who have hitherto investigated it have failed to arrive at concordant results, either because of the impossibility of obtaining absolutely pure metals, or by reason of the imperfections of the apparatus or the methods for electrical measurement at the date of their researches. When Mathiessen made his experiments (1863) it was extremely difficult to procure certain metals in a pure state. He mentions the labour necessary to produce 5 or 10 kilograms of pure metal, while now it is a matter of daily occurrence in some manufactories to deposit by electrolysis metals in a pure state by the ton. The processes employed in the establishment of the Nordeutsche-Affinerie, at Hamburg, as well as certain works in Belgium and England, lead to the extraction and separation of the metals from argentiferous copper ores, which contain small quantities of silver and traces of gold, not capable of separation by the older methods. This is profitably applied to ores in which the presence of the precious metals did not formerly affect the commercial value. Under such conditions it becomes easier and all the more necessary to review and complete former researches. This is the work that I have been able to undertake, by aid of the special facilities afforded me by a carefully fitted laboratory and a workshop in which are applied on a large scale processes which were not formerly applied outside the chemist's laboratory. I shall have the honour to resume before you the researches which I have pursued for some years. The results obtained are far from being complete, but they permit us to closely examine certain points of the theory of a subject upon which our ideas are not yet conclusively formed. They afford in all cases useful corrections to the published tables, which are for the most part afflicted with errors. This double claim is, I trust, sufficient to engage your kind attention. Researches relative to the conducting power of different bodies have been pursued only in recent times. Priestley was the first to attempt the determination of the conducting power of metals for a static charge of electricity. There was no precision in his method of comparison. He employed two wires of the same length and diameter, but of different metals, and sent charges through them until one was fused. The fused wire was considered the poorest conductor. Davy applied the same general method with voltaic currents, and succeeded in establishing the law relative to the dependence of electric resistance upon the length and cross-section of the wire. M. E. Becquerel, who has written a memoir on the origin of these researches, gives the table of relative conductivities, as measured by his father, who was the first physicist to engage seriously in this labour. The table is as follows:—

Copper	100	Iron	15·80
Gold	93·60	Tin	15·50
Silver	73·60	Lead	8·30
Zinc	28·50	Mercury	3·45
Platinum	16·40	Potassium	1·33

Since that time Pouillet has given the same measures and added the following table, which possesses a special interest from the fact that it exhibits the influence of the presence of foreign bodies, also of tempering and annealing:—

Palladium	5791	Copper, pure	3838
Silver (963 fine)	5152	Copper, annealed	3842
,, (900 ,,)	4753	Platinum	855
,, (857 ,,)	4221	Brass	200 to 900
,, (747 ,,)	3882	Cast steel	200 to 500
Gold pure	3975	Iron	600 to 700
,, (951 fine)	1338	Mercury	100
,, (751 ,,)	714		

The selection of a unit for comparison in this table is a matter of some interest. Pouillet has chosen mercury for his standard obviously for the reason that, being a liquid, it is the metal most easily obtained in a pure state, and that also, from this same property of liquidity, it is exempt from those variations of conductivity which arise from annealing, hardening, &c.

These considerations prompted the Congress of 1881 to select mercury for the material of the standard of resistance. At a second reunion of this Congress, this selection was approved, and the ohm was defined to be that amount of resistance offered by a column of mercury whose area of section is one square millimetre, and whose length is 106 centimetres, the temperature being 0° centigrade. The important researches of Becquerel, in 1846, led to the determination of the relative conductivity of several metals at the mean temperature of 12·75°. These results are exhibited in the following table:—

	Hammered.	Annealed.
Silver, pure, reduced from chloride	93·448	100
Copper, precipitated by battery and fused	89·084	91·439
Gold, pure	64·385	65·458
Cadmium	24·574	—
Zinc	24·164	—
Tin	13·656	—
Palladium	12·977	—
Iron	12·124	—
Lead	8·245	—
Platinum	8·042	—
Mercury (14°)	1·8017	—

Mathiessen afterwards published in the *Proceedings of the Royal Society* the following table, which has been accepted for practical use down to the present time:—

	Resist. in ohms of wire 1 m. long and 1 mm. diam.	Conductivity.
Silver, annealed	0·01937	100
,, drawn	0·02103	92·1
Copper, annealed	0·02057	94·1
,, drawn	0·02014	94·1
Gold, annealed	0·02650	73
,, drawn	0·02697	73
Aluminum, annealed	0·03751	51·6
Zinc, rolled	0·07244	26·7
Platinum, annealed	0·1166	16·6
Iron ,,	0·1251	15·5
Mercury, liquid	1·2247	1·58
Nickel, annealed	0·1604	12
Tin, pressed	0·1701	11·4
Lead, ,,	0·2526	7·6
Antimony, pressed	0·4571	4·2
Bismuth ,,	1·689	1·1
ALLOYS—		
Platinum 1, silver 1 (drawn or annealed)	0·3140	6·1
German silver (drawn or annealed)	0·2695	7·2
Gold 2, silver 1	0·1399	13·8

* Translated in *Van Nostrand's Engineering Magazine* from a communication to the Société Internationale des Electriciens.

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An examination of these tables shows a want of accordance not only in the relative conductivities of the different metals, but also in their order. Thus silver occupies the third place in the table of the elder Becquerel, whereas it should have been in the first. Also palladium is in the first place in Pouillet's table, while it should have been placed last. These differences justify the new researches, which are furthermore prompted by that desire for precision which the daily progress in the practical application of electricity renders necessary.

I now proceed to present a *résumé* of my researches in determining the resistance of metals and alloys; then the results of experimenting upon the influence of temperature, and finally, upon the relations more or less intimate between the electric and thermic conductivity. I shall hand to you a set of small bars which have been prepared for these experiments. These bars, as you see, have been cast with a diameter of about 13 millimetres. They have been cut in such a manner as to exhibit the grain of a fracture, and the detached portion has been drawn into wire, upon which the experiments now to be described were tried. In case of the alloys which cannot easily be drawn or rolled, as some of the compounds of silicon or phosphorus, the experiments have been tried directly upon the bars themselves by the method of Sir William Thomson. In conducting the experiments, the bars were supported upon V-shaped rests, placed at an invariable distance apart. These rests were respectively in communication with two resistances composed of two parts, of which one is one-thousandth of the other. A Wheatstone bridge, a differential galvanometer, a battery of four cups, and a contact key complete the apparatus. The measurements, which were very long and minute, and made upon a great number of specimens, were made in part by the writer at the workshop at Angoulême, with the assistance of Messrs. X. Muller and J. Stahl, engineers of the establishment, and partly by M. Duflon, electrical engineer in the measuring room of M. Sciami, director of the Maison Breguet. These latter experiments were those made upon the bars themselves. The number of specimens submitted to your examination is thirty-four. Their conductivities compared with silver and pure copper are given in the following table :—

Silver	100
Copper, pure	100
,, refined and crystallised	99·9
Bronze, silicious, telegraphic	98
Copper and silver alloy, equal parts	86·65
Gold, pure	78
Copper, with 4 per cent. of silicon	75
,, ,, 12 ,, ,,	54·7
Aluminum, pure	54·2
Tin, with 12 per cent. of sodium	46·9
Silicious bronze, telephonic	35
Copper, with 10 per cent. of lead	30
Zinc, pure	29·9
Phosphor-Bronze, telephonic	29
Brass, silicious, 25 per cent. of zinc	26·49
Brass with 35 per cent of zinc	21·5
Tin phosphide	17·7
Gold and silver alloy, eq. parts	16·12
Swedish Iron	16
Tin, pure ; banca	15·45
Antimony-Copper	12·7
Aluminium-Bronze	12·6
Siemens steel	12
Platinum, pure	10·6
Copper with 10 per cent. of nickel	10·6
Cadmium 15, mercury 85	10·2
Bronze, mercurial, dronier	10·14
Arsenical copper, 10 per cent. arsenic	9·1
Lead, pure	8·88
Bronze, containing 20 per cent. tin	8·4
Nickel, pure	7·89
Phosphor-Bronze with 20 per cent. tin	6·5
Copper with 9 per cent. phosphorus	4·9
Antimony	3·88

A large number of experiments were tried upon alloys and compounds not represented in the above series. It will be observed that in the results recorded above resistances are not given in ohms, but conductivities are expressed relatively to a selected standard, which is pure silver. A wire of this metal, one millimetre in diameter, offers a resistance at 0° centigrade of 19·37 ohms per kilometre. Pure silver and pure copper are the best known conductors of electricity. The ease with which silver can be obtained in a pure state would seem to entitle it to the position of standard of comparison. It also oxidizes with greater difficulty than copper, and its oxide is a better conductor. In this last peculiarity there is less chance of error when comparisons are made with silver for a standard. Gold has a conductivity of 78. The alloy of gold and silver calls attention to a remarkable fact. When silver is alloyed with a small percentage of gold, the conductivity immediately diminishes. Two per cent. of gold is sufficient to reduce the conducting power from 100 to 60. An increase in the proportion of gold, however, is attended with a decrease of conductivity at a less rapid rate, the minimum of 16·12 being the conductivity of an alloy of equal parts of gold and silver. If the varying conductivities of the different proportions of gold and silver alloy be represented by a curve, it will be found to take the form of a parabola whose axis is perpendicular to the axis of X, the curve descending from the ordinate 100 for pure silver to 16·12 for the alloy of equal parts of the two metals, and rising to 78 for pure gold. This singular phenomeon seems to indicate that a kind of interference is produced analogous to that when rays of light partially extinguish each other by superposition. This is not an explanation, but a simple analogy.

It should be remarked, however, that it is not true, though sometimes asserted, that in an alloy the electric conductivity is always lower than that of the poorest conductor of the constituents. It is simply demonstrated that the union of two bodies modifies to a great extent their separate conductivities, and this fact ought certainly to lead some time to interesting results. In examining the foregoing table, we find platinum with a conductivity of 10·6. Aluminium, which is distinguished from the other metals by its want of density, has the considerably higher conductivity of 54·2. This is partly compensated for by its low specific weight. But it is a mistake to consider its lightness as a quality fitting it some day for aerial telegraph lines. Its tenacity is rather feeble, and its tensile strength falls from 10 kilograms per square millimetre in the hard metal, to 6 or 7 kilos only in the annealed metal. Iron, steel, lead, zinc, and tin possess low conducting powers, and the results in the table are not insisted upon. It is sufficient to consider them in connection with results previously found. Copper, however, is to be regarded with interest and care, as it, with its alloys, is regarded as the typical conductor of electricity. It possesses when unalloyed and is free from its oxide a conducting power equal to silver. Its cost is low enough to render it available for industrial uses. It is malleable, and some of its alloys possess a remarkable tenacity. It is interesting to note the increase in the conducting power of copper with the improvement in manufacture. In the late discussion upon electric conductors, Mr. Preece exhibited the following table, showing the progress in conductivity of submarine cables :—

Submarine Cables.	Date.	Conductivity.
Dover-Calais	1851	42
Port Patrick-Donaghadee	1852	46
Transatlantic	1856	50
Red Sea	1857	75
Malta-Alexandria	1861	87
Persian Gulf	1863	89·14
Transatlantic	1865	96
Irish Sea	1883	97·9
Pure Copper	—	100

A similar progressive increase in the conductivity of the copper wire, furnished to the Administration Française des Télégraphes, which, after having for many years exacted a conductivity altogether indeterminate, so to speak, has been gradually led to adopt figures quite comparable to the highest in our table. The variation in the conductivity of copper is due to two principal causes: the presence of other bodies, and the presence of a varying quantity of copper oxide. Mathiessen and Holzmann have made a series of interesting experiments bearing upon this subject. Table A exhibits the conductivities of copper of different sections ; table B exhibits the conductivity of copper containing traces of different substances. These results are approximately the same as those we have obtained, and which we have already referred to. Table C exhibits the influence of the presence of copper oxide

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in the metal. The first five examples are of cold-drawn wire of pure copper.

It may be added as a commentary on the last results that in France pure copper wire is prepared by a special process, which completely eliminates the oxide. Copper thus prepared has the conducting power of silver. It has been measured recently by the telegraphic authorities mentioned above, and with the result of exhibiting a conductivity of 102 by the standard heretofore used, and whose imperfections were thus demonstrated. I cannot remember by what chain of circumstances I was led to study the compounds of copper and silicon, prepared for the first time by M. Henri St. Clair Deville, and apply them practically to the uses of the telegraph and the telephone. Coppers and bronzes prepared under such conditions are much used for aerial telegraph and telephone lines. Their electrical and physical qualities permit us to believe that the time is gone in which iron and steel enjoy the monopoly in such transmission. It is certain, as has been remarked by the eminent electrician in chief of the London Post Office: "Aerial lines should no longer be limited to the single quality of tensile strength. At a time when the apparatus for rapid transmission occupies all the great telegraphic routes, the lines should be made of very good conductors; the surfaces reduced so as to offer the least possible chance for induction, and they ought also to offer but little surface to the wind and snow, and should be practically indestructible." Mr. Preece does not hesitate to conclude that iron and steel wires have had their day, and they will soon be replaced by wires of copper and its alloys. The latter fulfil not only all the required conditions, but when once erected, cost no more than lines heretofore used.

(To be continued.)

TABLE A.

	Conductivity.	Temp. in deg.
1st. Spanish copper from Rio Tinto, containing 2 per cent. of arsenic, with traces of oxides of copper, lead, and nickel	14·24	14·8
2nd. Russian, Demidoff, with traces of arsenic, iron, and nickel oxides	59·34	12·7
3rd. "Tough cake," location not specified, traces of lead, iron, nickel, and antimony oxides	71·03	17·3
4th. ——, traces of iron, nickel, and antimony oxides	81·35	14·2
5th. Australian, Burra-Burra, traces of iron oxide only	88·86	14·0
6th. American, Lake Superior, 3 per cent. of silver, with traces of iron and copper oxide	92·57	15·0

TABLE B.

Copper with	Conductivity.	Temp. in deg.
2·50 per cent phosphorous	7·24	17·5
0·95 ,, ,,	23·24	22·1
0·13 ,, ,,	67·67	20·0
5·4 ,, arsenic	6·18	16·8
2·8 ,, ,,	13·14	19·1
Traces of arsenic	57·8	19·7
3·2 per cent. zinc	56·98	10·3
1·6 ,, ,,	76·35	15·8
Traces of zinc	85·05	10·3
1·06 per cent. iron	26·95	13·1
0·48 ,, ,,	34·56	11·2
4·90 ,, tin	19·47	14·4
2·52 ,, ,,	32·64	17·1
1·33 ,, ,,	48·52	16·8
2·45 ,, silver	79·38	19·7
1·22 ,, ,,	86·91	20·7
3·50 ,, gold	65·36	18·7
0·31 ,, antimony	64·5	12
0·29 ,, lead	64·5	12

TABLE C.

No.	Mode of preparation.	Conductivity.	Temp. in deg.
1.	Reduced by hydrogen	93·00	18·6
2.	Deposited by battery, not fused	93·46	20·2
3.	Commercial copper	93·02	18·4
4.	Ex. No. 3 remelted in hydrogen	92·76	19·3
5.	The same treated with a jet of hydrogen while fused	92·99	1·75
	(It has been noticed that the conductivity has been raised about 2½ per cent. by annealing.)		
	Copper containing an undetermined amount of oxide	73·32	19·5
	Deposited copper taken from a bar, fused on charcoal, and cast in an atmosphere of hydrogen	93·3	12·8
	Copper same as preceding taken from a porous bar cast in a mould under ordinary conditions	94·8	13
	Deposited copper, treated to cementation with charcoal, and containing silicon with traces of iron and phosphorus	62·8	13

ELECTROMOTIVE FORCES IN A VOLTAIC CELL.*

BY PROF. OLIVER LODGE.†

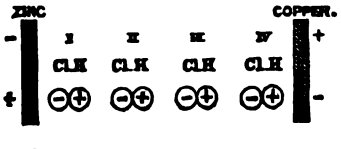
Theories of Wiedemann *and* Helmholtz.

In a recent *Beiblätter*‡, Prof. G. Wiedemann points out that in my summary of views and work in connection with the seat of E.M.F. in the pile I have ignored his theory. I had in fact been mainly concerned with possible explanations of the Volta-effect; while Prof. Wiedemann starts with this as a datum, and on the strength of it explains the action of the pile. Moreover, since most of the theoretical opinions hold on this subject are summarised at the end of the second volume of his *Elektricität*, while his own theory is given in the first volume, along with the account of Volta-force experiments, I had overlooked it. To make amends for this oversight, for which I beg to express my regret, and because I find it difficult to summarise his opinions briefly, I trust I may be permitted to give a rough semi-literal translation of his most conspicuous passages as a help to other students on the subject.

Theory of G. Wiedemann, 1870. (Wied., *Elek.* I., p. 251, *et seq.*)

"We have now to investigate in what way the electrical forces in a closed circuit of two metals and a liquid (*e.g.* Zn. Cu, dilute HCl) are excited. We know that the constituents of the binary compound contained in the liquid separate by the passage of the current in such a way that the one (H) is set free at the copper and an equivalent quantity of the other (Cl) at the zinc, and that the latter combines with an equivalent quantity of zinc to form ZnCl. This process shows that the deportment of the binary body between the metals consists no longer only in a simple overbalancing attraction of its whole mass for one or the other electricity, as in metals, but also in a special action of its constituents. Since the constituent Cl is liberated where the + current enters the liquid, and H where the negative enters, we suppose that each equivalent of Cl in the compound HCl is charged with a definite quantity of negative electricity, which conditions its attraction for the opposite positive electricity. It is the *electro-magnetic element* of the compound. So also must the equivalent H be charged with + E and form the electro-positive element. These charges could be produced by the combination of H and Cl exactly in the same way as they are produced by the contact of zinc and copper. Since the HCl formed is unelectrified, we must suppose that atoms of the + and − constituents contain equal qualities of + and − E.

"If now we immerse a Zn and a Cu plate into the dilute HCl, we can conjecture that the zinc has a stronger attraction for the electro-negative constituent (Cl) than for the H. In consequence of this the molecule of HCl touching the zinc will so lay itself that its electro-negative element is near the zinc and its electro-positive element near the copper. At the same time the molecules thus polarised act by electrical attraction on the constituents of the successive molecules of HCl, arranging the whole row of molecules between the Zn and the Cu plates as in the figure.



"By induction the negative electricity of the zinc-touching electro-negative constituent, chlorine, would act on the E in the zinc in such a way that the near parts will charge themselves positively, the further parts negatively. In the same way the copper adjacent to the electro-positive element (H) of the HCl atom lying against it will receive negative electricity. The positive will remove itself to the remoter regions.

"Thereupon the positive electricity in the zinc would combine with the negative of the next-lying Cl atom, and this latter with zinc to form unelectrical ZnCl. The electro-positive atom H which was formerly joined to that Cl atom would itself unite with the neighbouring atom of Cl belonging to the second atom of HCl, at the same time combining with the electricity contained in this atom; in the same way the hydrogen of the second atom—[the welcome letters *u. s. f.* are now not far ahead, and we will let them serve for the next fifteen or sixteen lines].

"It is evident that in this process there occurs a continual loss of *vis viva*, since the elements of the binary compound rushing up to the metal move with a definite velocity to the metal, and then are reduced to rest, either with formation of ZnCl or by being set free (H). This loss of *vis viva* is the equivalent of the heat which is evolved by the obviously occurring chemical process, which essentially is the solution of an equivalent of zinc in the acid. The same value must likewise be the work applied in effecting the redistribution of electricity.

"When, therefore, electricity begins to flow, work must be done, during the solution of Zn and liberation of an eq. of H from the liquid in the whole circuit, whether it be in the form of heat or of external work, which is equivalent to the heat-production attending that chemical process.

"The electrical shearing-force E is an accelerating force, so its work A in unit time is equal to its product with the quantity of electricity moved in unit time, *m*, and the distance *s* which the same travels, or

$$A = E.\ ms.$$

The product *ms* expresses the quantity of electricity which travels per second through the cross section of the conductor.

* Sequel to Paper on "The Seat of the Electromotive Forces in a Voltaic Cell," from the *Phil. Mag.* for October.

† Communicated by the Author, in continuation of paper in *Phil. Mag.* for March, April, May, and June of the current year.

‡ *Beiblätter zu den Annalen der Physik und Chemie*, 1885, No. 7, Band IX., p. 533.

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"If we have different combinations, as Zn, HCl, Cu; or Mg, H_2SO_4 or Na Cl, Cu; or &c., we suppose that the same quantity of E travels per equivalent.....[a long appeal to the facts underlying Faraday's law is made to prove this]; hence $ms = \text{const.}$,

$$\therefore A = \text{const.} \, . \, E;$$

or the E.M.F. is directly proportional to the heat generated by the decomposition of an equivalent of the binary compound and the solution of the zinc.

"For the production of steady currents, that electrical force can alone be active which depends on the unequal attraction and polarisation of the atoms of the binary compound in the exciting liquid of the cell; the electrical force at the contact-place of the metals which no mechanical changes can prelude must, on the other hand, be inactive. That this latter, if it perhaps opposed the metal liquid E.M.F. (as by immersion of zinc and lead in KCy solution), is not compensated by a definite part of the tension force, is proved by the aforesaid complete proportionality of the total electrical force (and E.M.F.) in the closed circuit with the said heat-equivalent of the chemical processes. It must then be neutralised in some other way. This would most simply happen on the hypothesis that, by contact of the existing fluid with the metals, the E.M.F. is excited in a double way: first, by an unequally strong attraction of the masses of fluid and metal *as a whole* for the one or the other electricity; and, secondly, by the unequal attraction of the metals for the oppositely electrified components of the liquid. (This double property would be quite analogous to the following: a metal (*e.g.* zinc) can not only attract to itself by adhesion the whole mass of any given fluid (HCl), but also can exert a much stronger attraction for one constituent of the same (chlorine); just also as a magnet attracts iron, not only by reason of gravitation, but much more because of the magnetic polarisation of its individual particles).

"In consequence of the first unequal (mass) attraction for the electricities, the decomposable liquids would behave exactly according to the metallic law of tension, and in a closed circuit of metals and liquids a complete neutralisation of electrical forces (and E.M.F.) would obtain; the second (chemical) action would, on the other hand, alone produce the electrical shearing-force effective in current formation and its accompanying E.M.F.

"We will therefore in the sequel denote the total E.M.F. at the various junctions with strong letters, and that portion of the same of which no part engages in exciting the current by italics in brackets, and by italics without brackets the portion corresponding to the chemical work. In the closed circuit—zinc, sulphuric acid, copper—the whole active E.M.F. would then be

$$\mathbf{Cu/S + S/Zn + Zn/Cu} = Cu/S + S/Zn + (Cu/S) + (S/Zn) + (Zn/Cu).$$

"The experiments of Hankel and others give the total E.M.F. between the metal M and water, which we denote by $\mathbf{M/Aq}$, and which is compounded, according to the foregoing hypothesis, of the E.M.F. excited by the mass action of the water (M/Aq), and that excited by reason of its chemical polarisation M/Aq. If therefore we put into water a copper and a zinc plate, the total potential difference, or E.M.F. between its ends, is $\mathbf{Cu/Aq + Aq/Zn}$. This is the quantity we should directly obtain if we connected the Cu and Zn immersed in water with the same named plate of a zinc-copper condenser, and after breaking the connection determined the charge of the condenser.

"On our hypothesis,

$$\mathbf{Cu/Aq + Aq/Zn} = (Cu/Aq) + (Aq/Zn) + Cu/Aq + Aq/Zn.$$

If we close the circuit by connecting the zinc and copper plate by a copper wire, the force $\mathbf{Zn/Cu}$ adds itself to these E.M.F.'s, and this force removes from the tension series of the metals the following forces $(Cu/Aq) + (Aq/Zn)$; wherefore we get

$$\mathbf{Cu/Aq + Aq/Zn + Zn/Cu} = Cu/Aq + Aq/Zn.$$

But this last is the part of the total E.M.F. applied to the formation of the current. Hence *to the directly found contact-forces between different metals and water we must add the electromotive excitation of one metal on the other in order to get the current-forming E.M.F. in the circuit of a closed cell.*"

So far as I am able to see to the bottom of the foregoing theory its foundation appears to be as follows:—Contact experiments compel us to accept the summation law for the Volta-effects, or total differences of potential,

$$\mathbf{E = Cu/Aq + Aq/Zn + Zn/Cu.}$$

The chemical theory constrains us to admit that the E.M.F. of a cell is the equivalent of the chemical action going on, and thus suggests that it equals the sum of some chemical contact forces; or, in Wiedemann's notation, E ought also to equal

$$Cu/Aq + Aq/Zn.$$

How are these two requirements to be reconciled?

Assume that at every junction there is a total force made up of two portions—a chemical force, such as Cu/Aq, and a physical force, which may be denoted by (Cu/Aq), and write the whole E.M.F. of a cell equal to the sum of these chemical and physical junction-forces,

$$E = Cu/Aq + (Cu/Aq) + Aq/Zn + (Aq/Zn) + (Zn/Cu).$$

We have then only to make the physical forces obey Volta's series law; so that

$$(Cu/Aq) + (Aq/Zn) + (Zn/Cu) = 0;$$

and we get the required relation

$$E = Cu/Aq + Aq/Zn,$$

which harmonises chemical and contact views.

Prof. Wiedemann's reconciliation of contact and chemical theories would thus seem to be somewhat of the same order as the later and less complete one of Fleeming Jenkin, quoted in my paper, § 6; but I cannot help feeling that the theory of Prof. Wiedemann is rather fuller of hypothesis than most other contributions to the subject with which I am acquainted; for it postulates

1. An unexplained difference of potential between metals in contact.
2. A similar difference of potential between the elements of a compound.
3. An unequal attraction of bodies for + and − E.
4. An unequal attraction of metals for chemical elements.
5. A chemical contact-force between metals and liquids, depending on No. 4, not obeying Volta's law.
6. A physical contact-force, depending on No. 3, obeying Volta's law.
7. Proportionality of the chemical contact-forces and the heats of combination.
8. A mechanical falling together of atoms accounting for heat-production at electrodes; and
9. That electrical actions go on between the molecules of a liquid, and between those molecules and metals immersed in it, according to the ordinary laws of electrostatics.

Not all of the above hypotheses, however, are to be regarded as independent: the dependence of Nos. 5 and 6 is stated, and it is possible that some of the others are intended to be likewise dependent, though I do not clearly see how.

In some of these hypotheses, for instance, Nos. 4 and 5, and with considerable differences, Nos. 6 and 7, Prof. Wiedemann's theory bears a resemblance to the views set forth by the present writer in the paper to which this communication is a sequel.

One obvious objection may be taken to the theory on a question of fact. According to it, zinc half immersed in water is negative to copper half immersed in water (see diagram above): but experiment has failed to exhibit anything of the kind; but it is well known that Sir W. Thomson, Prof. Clifton, and others have shown that zinc and copper immersed in water or dilute acid are electroscopically at the same, or nearly the same, potential.

Theory of Von Helmholtz, 1847 *and later.*

There is another theory which I did not indeed ignore, but which I passed over with very insufficient mention, in the paper referred to (see footnote to § 9, *Phil. Mag.*, April, p. 258), viz., the theory of Prof. von Helmholtz, which he first stated in his great memoir of 1847, *Die Erhaltung der Kraft*, and which he has improved and elaborated since (see Faraday Lecture of 1881).

This fascinating theory has a small hypothetical basis, viz., Nos. 3 and 9 of the above list; and on this foundation is erected an explanation of the Volta effect, a theory of electrolysis, and a great part of a theory of chemical combination.

Once grant (1) that every substance has a specific attraction for positive or for negative electricity which can be exerted only through molecular distances, and (2) that the laws of electrostatics may be applied to the charges of atoms in a liquid; and the ease with which a multitude of phenomena are explained is surprising. I do not feel certain that a little too much is not explained; but we can postpone the consideration of possible objections until the theory itself is briefly stated.

Metals, and "electropositive" elements generally, attract positive electricity or positively electrified atoms whenever these come within range, *i.e.*, within some molecular distance of the surface. Potassium and zinc attract strongly, copper and gold feebly. Oxygen, chlorine, and other "electronegative" elements, attract negative electricity in a similar manner.

Bring now two metals, say zinc and copper, into contact, and the superior attracting-power of zinc for positive electricity will at once charge it at the expense of the copper, so that the zinc touching-surface becomes strongly positive, and the copper surface strongly negative. Separate the metals, and they mostly discharge into each other; but a feeble charge remains if the surfaces in contact were large, and if they had been neatly separated; and this is the Volta effect.

Moreover, since each metal has a definite attracting-power depending on itself only, Volta's series law is an obvious necessity.

If one of the substances had been an insulator much less loss need take place while separating them, and accordingly high charges are then found upon them even after separation ("frictional electricity.")

Now, consider similarly two *atoms* in contact, forming, say, a water molecule. The hydrogen will be positively charged, and oxygen negatively. If some atoms should get knocked asunder they retain their charges and therefore tend to unite again, but, while separate, their mutual attractions and repulsions will preserve a uniformity of distribution throughout the liquid—*e.g.* the repulsion of similar charges will prevent a number of oxygen molecules crowding together; and if any cause should remove oxygen atoms from any part of the liquid, the vacancy will be instantly supplied by similar atoms repelled there.

The remarkable thing about the charges of atoms is, however, that they are all equal, and even for different atoms are still the same, or differ only according to simple multiples of some one absolute quantity; so that one atom may have three times as much negative electricity as hydrogen has positive, but not any fractional number. Such an atom may therefore combine with three of hydrogen atoms, and thus be called a triad. Another may be a dyad, &c. A given constant charge belongs to every unit of affinity which the atom possesses; and thus is the fact of chemical equivalence stated, though not accounted for. Faraday's law compels us to believe that atomic charges are thus multiples of one definite electric

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quantity, but why they should be so we are wholly unable to say. It looks as if electricity were atomic as well as matter; a sufficiently startling idea, as Helmholtz says.

Chemical affinity is thus due to the electrical attraction of oppositely charged atoms; not so much due to the attraction of the atoms themselves. This latter kind of attraction Helmholtz would not indeed deny, and he considers it may account for "molecular" modes of combination; but he regards it as much weaker than the electric forces, and not as effecting definite chemical combinations.

We have ideas now concerning the size of atoms, and can calculate roughly what an atomic charge is. The charge of each atom is but small, but the aggregate charge of an appreciable number of them is enormous. It can be easily reckoned that if you take the opposite electricities out of a milligramme of water and give them to two spheres a mile apart, those two spheres will attract each other with a force of ten tons! Or, again, the electrical attraction of two atoms at any distance exceeds their gravitative attraction 71 thousand billion times. Upon such charges as these even very feeble external electrical influence may exert considerable force, and quite everpower any other kind of chemical affinity.

Plunge, therefore, two platinum plates into the liquid and keep them at some slightly different potential, say a volt or two: their surfaces are oppositely charged, and even this feeble charge may be sufficient to tear asunder the atoms of molecules which come close up to it.* If it is not sufficient, it will at least hold a layer of oppositely charged atoms facing toward it across molecular distance; so that near each plate we have an excessively thin condenser of enormous capacity; but in the mass of the liquid is no such strain, the slightest E.M.F. being sufficient to redistribute the atoms here and to produce perfect equilibrium. If the atoms are torn asunder by the electrode and liberated, fresh ones are continually supplied by the rest of the liquid, the state of strain being constantly re-formed and instantly broken down.

Thus are the phenomena of polarisation and electrolysis explained.

Now insert into the liquid a pair of plates of zinc and copper in contact. By the contact the zinc has become positive and the copper negative, and accordingly the zinc attracts the oxygen (or SO_4 radical) and combines with it: the copper attracts the hydrogen, and does the best it can with it.

This crudely is Helmholtz's view of a voltaic cell.

There is, however, one important detail not yet mentioned. I have spoken as if the work done by an electrode were to tear the atom from its combinations. This is not exactly Helmholtz's view. He adduces arguments to show that the work required to effect decomposition has for its object, not the separation of the atom from the liquid, but the separation of the atom *from its electric charge*. It is to this that it clings, and this that has to be taken from it. If it be made to give up this by a sufficient E.M.F., it is of small or no moment whether the ion be really set free, or be dissolved, or otherwise kept in the liquid. But when the electrode is of such a metal that an ion can combine with it, that ion retains its charge, and accordingly very little E.M.F. is sufficient to decompose the liquid under such circumstances.

Without this statement it might be objected, that when a piece of zinc is plunged into acidulated water, since it has a strong attraction for positive electricity, it ought to attract the positively charged *hydrogen* atoms up to itself, instead of oxygen as commonly supposed. I suppose Helmholtz would admit that it must do this to begin with, when isolated from other metals, on his theory, but that it has no way of separating and liberating atoms because it cannot get rid of their charges. If it be kept at a sufficiently negative potential artificially it can indeed dispose of these charges, and it then does attract and liberate hydrogen. But contact with copper raises it to a *positive* potential, and it then attracts negatively charged oxygen, rather than hydrogen, and combines with it; while the negatively electrified copper seizes hydrogen atoms, tears their charges away from them, and sets them free.

I must confess, however, that I feel a difficulty here. The natural tendency of zinc is, by hypothsis, to attract positive and repel negative atoms; but, while a very feeble positive electrification applied to it is sufficient to reverse this tendency, a comparatively strong negative electrification is needed to enable it to exert that force which by the hypothesis is supposed to be *natural* to it.

In considering a Daniell cell, zinc/$ZnSO_4$/$CuSO_4$/ copper, Helmholtz obtains the energy producing the current, by pointing out that electricity is removed from copper, which only attracts it feebly, and given to zinc which attracts it strongly. Zinc goes into solution and becomes positively charged, while an equivalent of equally positive copper comes out; and since this results in a gain of energy, it follows that electricity must do more work in going to zinc, than in going to copper.

But if zinc attracts electricity so much more strongly than copper, why is it so easy to drive electricity across a copper/zinc junction? And why does no energy manifestation result at the junction from such an operation?

The answer probably is, because of the large charge already existing at the junction; the zinc has pulled as much positive electricity out of the copper as it wants, and there exists at the contact an electrical double layer, whose existence makes it quite easy for extraneous electricity to flow either way across the junction.

But, then, if zinc pulls so much electricity out of a piece of copper with which it is put into contact, where does it all come from? And why does it not leave the copper *strongly* negative instead of only feebly so, as evidenced by Sir W. Thomson's electrified-needle form of experiment? Why, again, does this method of observing the Volta-effect, with the plates permanently in contact, agree so well with the old method of observing it by separation of the plates, if a great but uncertain part of the charge leak back as soon as separation beyond molecular distance is attempted?

These and similar difficulties occur to me in connection with this most interesting theory; and I state them, not with any idea that they are final and unanswerable, but because it is always serviceable to point out the apparent defects of the theory as well as its merits.

It will be seen that, whereas Helmholtz's theory starts with a hypothetical differential attraction of *matter for electricity*, and explains the chemical attraction of matter for matter on the strength of it, my view starts with a differential chemical attraction of *matter for matter* (*i.e.* zinc attracting oxygen more than copper attracts it), and on this basis works out the theory of the voltaic cell and of the Volta-effect.

In electrolysis proper both views may be at one, because here we are concerned with electrical attractions only; but Prof. Helmholtz's has the advantage, because it explains the fact of atomic charges, which mine has to assume. My view of electrolysis has hitherto been much less electrostatic than Prof. Helmholtz's, but also it has been much more vague. A great deal is to be said for the assumption of ordinary electrostatic attraction over molecular distances, and by adopting such more definite ideas I am in hopes of improving my theory further. And though, after all, none of these views can be really absolute, because they begin and end with action at a distance, still electrostatic attraction is a fact, and we know that it can be accounted for by a strain in a continuous medium. Hence phenomena reduced to electrostatics may be held to be provisionally "explained."

But beyond electrostatic attraction some other primary force is necessary; either *chemical affinity*, the attraction of atom for atom, or *electrical affinity*, so to speak, the attraction of atoms for electricity.

Chemical affinity is a fact, however, to be accounted for; but, to enable it to explain everything, the fact of atomic charge must be permitted to likewise go without explanation. These are the necessary data for my view.

"*Electrical affinity*" is not known to be a fact; but if it be granted, everything is explained (barring a few outstanding difficulties), even the fact of atomic charge itself, though not its numerical exactitude. This is the datum required for Helmholtz's theory.

It may thus be said that while the writer's view rests on two admitted facts which it does not attempt to explain, but, assuming them, explains other things from them; Helmholtz's theory rests on one unverified hypothesis, which, being granted, everything else follows; except indeed the numerical *equality* of atomic charges, which has to be regarded as experimentally demonstrated in both theories.

According to my view, the zinc of a cell pulls up the negatively charged oxygen atoms (or SO_4 radicals, whatever the real ions may be) to itself, not because they are electrified, but because they are oxygen. The electrical current produced is a secondary result caused by the chemical action.

According to Helmholtz, the zinc pulls the oxygen atoms because it is itself electrified by contact with copper, and because they are oppositely electrified by contact with hydrogen. The chemical action resulting is a secondary result caused by the electric forces.

Helmholtz's is thus a true "contact theory," and is in many respects like Sir W. Thomson's. Sir William postulates an attraction of zinc for copper, and from this explains the Volta-effect and the production of a current. I am unable to picture to myself exactly *how* the attraction of zinc for copper results in a difference of potential when they are put into contact; but undoubtedly such a force, if granted, would put a supply of energy at disposal which could account for the Volta-effect. And a difference of potential thus set up may result in an electrical decomposition of water and maintenance of current, just as in Helmholtz's theory.

I must confess that I am unable to feel quite comfortable about energy considerations with either of these theories of the voltaic cell; because it seems as if the metallic junction were, after all, driving the current, whatever be said about chemical energy. But in this I must certainly be

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* It is easy to calculate the surface-density, and the difference of potential, on the above hypothesis, needed to tear asunder oppositely charged atoms attracting each other across molecular distance x. Let it be σ, and let the charge of an atom be q; then

$$2\pi\sigma q = \frac{q^2}{x^2}.$$

Moreover we know that 19,320 electromagnetic units can decompose 18 grammes of water, which allows $536+3+10^{10}$ electrostatic units of each kind of electricity per gramme; so if n^3 be the number of molecules in a gramme of water, the charge of each dyad atom is

$$q = \frac{1\cdot6\times10^{13}}{n^3}; \quad \text{or} \quad 1\cdot6\times10^{-11} \text{ probably.}$$

Hence,

$$\sigma = \frac{1\cdot6\times10^{13}}{2\pi n^3 x^2}; \quad \text{or} \quad 3\times10^{-12} \text{ probably;}$$

and, the difference of potential between either plate and liquid being given by $4\pi x\sigma$, the whole difference of potential between the electrodes is

$$V = 8\pi x\sigma = 6\cdot4\times\frac{10^{13}}{n^3 x}; \quad \text{or} \quad \cdot0064 \text{ electrostatic units probably,}$$

or 1·92 volt.

In reckoning the approximate numerical values above, I have assumed that $n=10^8$ and that $nx=1$. The resulting decomposition force comes out, quite accidentially as far as I am concerned, very near that needed to decompose acid-water. But I need hardly point out that *order of magnitude* is all that is really calculated in these figures; and that not only decimals but even numerals, prefixed to the power of 10, have very little meaning. The value of x may perhaps vary somewhat for different substances; and as to the value of n, though that is definite enough, it is very probable that it ought to be something more like 2×10^8 than what I have above assumed it.

It is at any rate satisfactory that the electrostatic hypothesis should give, as a polarisation E.M.F., a number so entirely comparable with actual results.

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wrong; that is to say, there must be some thorough way of reconciling these, by such men advocated, views with energy considerations, though I am unable satisfactorily to perceive it.

Both these contact-theories, in explaining the Volta-effect, ignore the existence of the oxidizing medium surrounding the metals. My view explains the whole effect as a result of this oxygen bath, and of the chemical strain by it set up. The other theory, which likewise took account of the atmosphere is the old chemical one; but this leaves the aspect of the matter exceedingly vague. The strictures applied to it by Prof. Helmholtz (Faraday Lecture, 1881) are well deserved:—

"The so-called chemical theory of Volta's fundamental experiment was rather indefinite; it scarcely did more than tell us—here is the possibility of a chemical process, here electricity can be produced. But what kind, how much, to what potential, remained indefinite. I have not found in all the papers which have been written for the defence of the chemical theory a clear explanation why zinc opposed to copper in liquids, where zinc really is oxidized and dissolved, becomes negative, and why in air and other gases it becomes positive, if the same cause (viz. oxidation) is at work."

To the chemical *strain* theory, held by me, none of this remark is in the least applicable. This theory *does not say* that zinc opposed to copper in a liquid is negative. It says that, changing the surrounding medium from air to acid-water, makes scarcely any difference; and that accordingly connecting zinc and copper by a drop of water leaves them with the same respective potentials as they had before. The strain of oxygen-atoms towards a metal exists whether in air or water, but it can produce no effect in either case until at some point the oxygen be swept away by contact with another metal. Then instantly the chemical forces are able to do work, and to produce, if in air or other dielectric, the Volta-effect; if in acid or other electrolyte, the voltaic current. The metallic contact equalises the potential of the two metals in the one case; in the other it perpetually *fails* to equalise their potential. The equalisation of an otherwise disturbed potential is its only effect.

And no indefinitiveness exists as to either the kind or amount of the Volta-effect as so produced, for I have shown fully that *a* Volta-effect can be calculated in absolute measure for any pair of clean metals immersed in any medium, from purely thermo-chemical data; but whether this effect is the real one or not is at present a matter of opinion.

These so-calculated effects undoubtedly agree in some cases with experimentally observed ones; but whether they all so agree, and, if not, the extent to which they are erroneous, are matters mainly for future experiment to decide; and upon such agreement or disagreement between calculation and experiment my theory definitely stands or falls.

THE DISTRIBUTION OF ELECTRICITY.*

BY PROF. GEORGE FORBES.

LECTURE I.—INTRODUCTORY.

(Continued from page 416.)

I have now gone fully into the question of the most economical size of conductors. But it is one of prime importance in the whole of our problem; and, in conclusion, I will furnish you with a table which I find to be of great use.

The engineer can choose his facts for himself absolutely, can choose what he considers to be the right value of the electrical horse-power every year for the number of hours he proposes to run. He can also choose the cost of copper which he thinks it will suit him to lay. Having done that, he proceeds in this manner: I will take as an example copper costing £100 a ton; take 7½ as the rate of interest; I look along the column of Table II*b*. (p. 441) until I find £100, look down until I come to 7½, and find the figure ·316. I then look to the top of the Table II*a*. (p. 441), and I have £8 a year, say, for my electrical horse-power. I look along the column of £8 a year until I find the figure nearest to ·386, and I find that it comes to a place beneath the number 2·7; in that case 2·7 would be the square inches which are required for the main on those conditions imposed by the engineer himself. I have given another table (p. 441) for continual reference, showing the resistance of 100 yards and various other facts, also the current which will heat the wire.

Before leaving the subject of the cost, allow me once more to impress upon you that I consider this matter of primary importance, and no consideration must ever lead the engineer to deviate from the strict rules which regulate the cost. It may be in some special cases not always practicable to regulate our wires to carry the current exactly at this rate. It may be because it is easy to get a stock of conductors at slightly different size, or it may be inconvenient to be always varying the estimate in the size. But these principles must be gone into for every part of the scheme, and in our practical application we must stick as closely to our results arrived at there as we possibly can. It is no use for the engineer to say that financial people will not bring forward the money for these costly mains. The engineer, in my way of looking at it, has no right to look at what the financiers want to do. He must tell them honestly what is the most economical thing to do. If the financier wants to lay out capital in a particular direction, knowing that he will be causing a waste of energy, the engineer ought to have nothing to do with such matters. He ought honestly to give the value of the current which is most economical.

I have dealt now fully enough with the first cause that prevents us from diminishing the thickness of our conductors. The second cause why we should not reduce too much is the heating of the conductors. There are in this three injurious facts; in the first place, it spoils the insulation; the insulating power of the material diminishes by being heated, and the material itself becomes injured; moreover, when it is hot, it usually becomes soft, and the conductors can sink into it, and thus become decentralised. And in the second place, the conductors themselves are injured, because their resistance is increased by the increase of temperature, and these increases of temperature, mark you, are very considerable. And in the third place, the increase of temperature may be very serious, and may actually be objectionable along the streets. I have here a small piece of cable which shows the decentralising action of bituminous compound. This has been lying for six or eight months in a cool part of a cool room, always lying in the same position. I believe when I got it it was perfect, but in a cool place it gradually sunk, and now it is very decidedly out of centre. An old experiment which I used to show when I held my chair at Glasgow illustrates the viscosity of objects. It was first suggested to me, and I first saw it done, by Sir William Thomson in his laboratory. A block of hard brittle pitch—or shoemakers' wax would serve the same purpose—is set with a bullet on the top and corks underneath; in six months the bullet will have sunk into the pitch, and the corks will have risen several inches up through it. This simply shows you how such bituminous compounds must be carefully watched, and how very objectionable is any viscous material in the way of decentralising the conductor.

Now, as to the question of heating conductors, I will not take up much of your time this evening, because I have already, in a paper which I read at the Society of Telegraph Engineers last year, gone into the question very fully. It used to be supposed by some that if the currents in different wires were proportional to the section of the wire, the heating would be the same in all. This is not so, and when we look into the matter we could not expect it to be so. Heat is generated in a wire at a steady rate, and, if the temperature of the wire has reached a stationary condition, the same quantity of heat is carried off from the surface of the wire.

I showed by experiment, in 1882*, that to give the same heating in different wires (when these wires are small) the diameters of the wires should be nearly proportioned to the currents they have to carry.

I will show you by a simple experiment that if the currents should be proportional to the section, the thicker wire would get hottest. Here I have two wires of the same length; one is ten times the thickness of the other. I unite their ends in parallel and send a current through. The current splits up into two parts proportioned to the section of the wires. Both wires get hot, but the thick one hottest, as you see by its white incandescence, whilst the other is not luminous.

I only draw your attention to the question now because there is an important point which, I am glad to say, needs correction. A discovery has been made of an error near the end of the paper which might be misleading, and which probably has misled some. I will give you a corrected edition of it.

Here is the table to which I have referred. It gives you underground conductors. I have recommended sheets of copper for underground conductors, because the temperature is far less raised when you have a thin conductor.

Width in inches, of copper conductor, 1 cmr. thick.	Cross-section in square inches.	Current to raise surface temperature 10° C.
		amperes.
3·2	0·25	250
12·7	0·98	1,000
38·1	2·95	3,000
63·5	4·92	5,000
127·0	9·84	10,000
889·1	68·88	70,000

This is a most important point. We have absolute control over the temperature; by widening out our sheet we have diminished temperature, and can make the heat of conductors subservient to economy.

It is not essential that copper sheet should be used. The same mass of copper put into rods, or wires side by side, would produce the same effect if the average thickness of copper continues to be one centimetre, and these rods might be insulated in any way, or put in pipes. The depth at which these are laid does not affect the heat of the surface of the pavement so long as the depth does not exceed two feet, but the temperature of the conductor itself is greater at the greater depth.

It is satisfactory to find that the considerations of heating the insulation and heating the surface of the pavement, lead to the same result as that of economy—viz., that we should have 1½ square inch per 1,000 amperes of current.

I pointed out that if you do not bury your conductors more than about two feet the surface temperature is not affected; only the temperature of the conductor. If you go two feet deeper, you will affect the surface temperature also. I have thought that up to 10° C. is the limit endurable by foot-passengers. In the summer the rising temperature of the pavement is most objectionable. Fortunately this is the time when the current is least used. Moreover, the temperature does not immediately pass through the ground. The daily variations of surface temperature differ as the diurnal change of position of the sun. It does not penetrate very deep down—is very slightly perceptible at two feet depth. If we have 500 amperes flowing for 24 hours, the effect would be almost exactly the same as if 1,000 amperes were flowing for six hours. Another point—instead of laying a sheet one centimetre thick, you might lay cables with the same result, provided the average thickness was one centimetre.

* The Cantor Lecture of Professor George Forbes, delivered on February 2nd, 1885. From the *Journal of the Society of Arts.*

* British Association Report.

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In speaking of the economical size of conductors, I arrived at the conclusion that I might use 2·7 inches, or say three inches for 1,000 amperes; but, mark you, though 1,000 amperes is the average current, it is not the maximum current to pass through that conductor. The maximum is a very different thing indeed to that. When we have an average of 1,000 amperes, it does not in the least mean that that is the average quantity of current which is flowing through it, because the wasted energy depends upon the square of the current. This leads to a very different law, and a very important one, about which I have a word or two to say. Suppose n_1 is the number of hours during which a quarter of the lamps are burning, n_2 one-half, n_3 three-quarters, and n_4 the number of hours during which all the lamps are burning, then the ratio of average current to maximum current is—

$$\sqrt{\frac{(\frac{1}{4})^2 n_1 + (\frac{1}{2})^2 n_2 + (\frac{3}{4})^2 n_3 + n_4}{n_1 + n_2 + n_3 + n_4}} = a.$$

The table in the next page gives a for different values of n_1, n_2, n_3, and n_4.

Thus the average quantity can be got from the maximum quantity by multiplying by the correct value of a. If half the lamps are burning two-thirds of the time, and the rest of the time all the lamps are burning, we get $a = ·5$. Therefore, instead of having 2·7, we only have 1·35 as the actual area for 1,000 amperes. As a matter of fact, I shall select for the rest of the lectures ·5 as the value for a, and hence 1·5 square inch to the maximum current of 1,000 amperes. It seems to me, for a working hypothesis—which no one need adopt—a good enough value.

The third reason why we cannot reduce the size of the conductors too much is that the potential falls, and the thinner the conductor the greater the fall of potential between the dynamo and the lamps. With a large current there is a great fall of potential (experiment shown), thus showing that in a central lighting station the fall of pressure, and, therefore, the brightening of the lamps in the district, depends upon the number of the lamps in use at the time. This is a serious thing, and the most difficult engineering problem with which we have to deal. We have

TABLE I.

B.W.G.	Diameter in Inches.	Section in square inches.	lb. copper per 100 yds.	Resistance per 100 yards at 15·5° C., or 60° F.		Wire heated to θ° above temp. of air.		Wire heated to 26° above temp. of air.	
				B.A. Units.	Legal Ohms.	Current.	Loss in Volts per 100 yds.	Current.	Loss in Volts per 100 yds.
	2·26	4·0	4608·	·000634	·000627	1514·	·998	2490·	1·730
	2·11	3·5	4032·	·000724	·000716	1384·	1·042	2246·	1·783
	1·95	3·0	3456·	·000845	·000835	1228·	1·079	1995·	1·847
	1·78	2·5	2880·	·00101	·000999	1072·	1·125	1739·	1·931
	1·60	2·0	2304·	·00127	·00126	913·	1·205	1482·	2·059
	1·38	1·5	1728·	·00163	·00161	732·	1·288	1188·	2·187
	1·13	1·0000	1152.	·00253	·00250	542·1	1·426	880·0	2·446
	1·00	·7854	904·78	·00326	·00324	451·5	1·513	732·7	2·586
	·75	·44178	508·93	·00584	·00578	293·0	1·746	475 5	2·991
	·707	·39250	452·16	·00653	·00651	268·0	1·800	435·2	3 081
	·500	·19635	226·18	·01307	·01292	159·4	2·139	258·6	3·659
0000	·454	·1618	186·39	·01567	·01550	138·1	2·248	224·1	3·854
000	·425	·1419	163·47	·01786	·01766	125·1	2·323	203·0	3·977
00	·380	·1134	130·64	·02236	·02211	105·7	2·456	171·4	4·201
	·354	·09842	113·37	·02605	·02576	95·1	2·546	154·3	4·357
0	·340	·09079	104·60	·02824	·02793	89·4	2·594	145·1	4·442
1	·300	·07068	81·42	·03637	·03597	74·0	2·755	120·1	4 722
2	·284	·06334	73·00	·04048	·04003	68·63	2·850	111·4	4·880
3	·259	·05268	68·68	·04867	·04823	59·60	2·981	96·7	5·102
4	·238	·04448	51·61	·05764	·05700	52·37	3·102	85·0	5·315
5	·220	·03801	43·78	·06740	·06665	46·5	3·213	75·5	5·521
6	·203	·03236	37·27	·07937	·07849	41·27	3·360	66·97	5·762
7	·180	·02544	29·3	·1006	·08943	34·31	3·553	55·69	6·084
8	·165	·02138	24·62	·1199	·11857	30·25	3·728	49·09	6·384
9	·148	·01720	19·81	·1492	·14643	25·28	3·878	41·03	6·630
10	·134	·014102	16·25	·1812	·17919	22·12	4·133	35·90	7·075
11	·120	·011309	13·00	·2267	·22418	18·74	4·366	30·41	7·473
12	·109	·009331	10·74	·2748	·27175	16·25	4·589	26·38	7·857
13	·095	·007088	8·16	·3617	·35769	13·09	4·866	21·25	8·332
14	·083	·005410	6·23	·4739	·47064	10·84	5·280	17·58	9·031
15	·072	·004071	4·68	·6298	·62281	8 723	4·646	14·14	9·652
16	·065	·003318	3·82	·7727	·76412	7·481	5·931	12·14	10·169
17	·058	·002642	3·04	·9711	·96032	6·371	6·354	10·24	10·771
18	·049	·001885	2·07	1·3598	1·3447	4·876	6·813	7·95	11·691
19	·042	·0013854	1·60	1·8502	1·8297	3·883	7·385	6·31	12·658
20	·035	·0009621	1·108	2·6650	2·6354	2·953	8·087	4·80	13·866

Legal volts. 96 per cent. conductivity copper. Heating of bare copper wire, emissivity = ·00025 C.G.S. units.

TABLE IIa.—Section per Thousand Amperes in Inches.

Annual Cost of Electrical Horse-power £	1	1·1	1·2	1·3	1·4	1·5	1·6	1·7	1·8	1·9	2	2·1	2·2	2·3	2·4	2·5	2·6	2·7	2·8	2·9	3·0	3·1	3·2	3·3	3·4	3·5	3·6	3·7	3·8	3·9	4	4·5	5·0	5·5	6·0
5	1·628	1·356	1·147	·980	·857	·746	·658	·585	·523	·471	·426	·386	·355	·324	·298	·276	·255	·237	·221	·206	·192	·180	·170	·160	·150											
6	1·954	1·627	1·377	1·176	1·028	·895	·790	·702	·628	·565	·511	·463	·426	·389	·358	·331	·305	·284	·265	·247	·230	·216	·203	·192	·180	·170									
7	2·279	1·898	1·606	1·372	1·199	1·044	·921	·819	·733	·660	·596	·540	·498	·454	·417	·386	·356	·331	·309	·288	·269	·252	·237	·224	·210	·199	·188								
8	2·605	2·169	1·836	1·568	1·370	1·194	1·053	·936	·838	·754	·682	·618	·569	·518	·477	·442	·407	·378	·353	·329	·307	·288	·271	·256	·240	·227	·215	·203							
9	2·930	2·441	2·065	1·764	1·542	1·343	1·185	1·053	·942	·848	·767	·685	·640	·583	·536	·497	·458	·426	·397	·370	·346	·324	·305	·288	·270	·256	·242	·229							
10	3·256	2·712	2·295	1·960	1·713	1·492	1·316	1·170	1·047	·942	·852	·772	·711	·648	·596	·552	·509	·473	·441	·411	·384	·360	·339	·320	·300	·284	·269	·254	·241	·229					
11		2·983	2·524	2·156	1·885	1·641	1·448	1·287	1·152	1·037	·942	·849	·782	·712	·656	·607	·560	·520	·485	·452	·422	·396	·373	·352	·330	·312	·296	·279	·265	·252	·240				
12			2·754	2·352	2·056	1·790	1·580	1·404	1·256	1·131	1·027	·926	·853	·778	·715	·662	·611	·568	·529	·493	·461	·432	·407	·384	·360	·341	·323	·305	·289	·275	·262	·206				
13				2·548	2·227	1·940	1·711	1·521	1·361	1·225	1·108	1·004	·924	·842	·775	·718	·662	·615	·573	·534	·499	·468	·440	·416	·390	·369	·350	·330	·313	·298	·283	·224	·181			
14					2·398	2·089	1·843	1·638	1·466	1·319	1·193	1·081	·995	·907	·834	·773	·713	·662	·617	·575	·538	·504	·475	·448	·420	·398	·379	·356	·337	·321	·305	·241	·195	·162		
15						2·238	1·975	1·755	1·570	1·414	1·278	1·158	1·066	·972	·894	·828	·764	·710	·662	·617	·576	·540	·509	·480	·450	·426	·404	·381	·362	·344	·327	·258	·209	·174	·147	
16							2·106	1·872	1·675	1·508	1·363	1·235	1·137	1·037	·954	·883	·814	·757	·706	·658	·614	·576	·542	·512	·480	·454	·430	·406	·386	·366	·349	·275	·223	·186	·156	
17								1·990	1·780	1·602	1·448	1·312	1·208	1·102	1·013	·938	·865	·804	·750	·699	·653	·612	·576	·544	·510	·483	·457	·432	·410	·389	·371	·292	·237	·199	·166
18									1·884	1·696	1·534	1·390	1·279	1·166	1·073	·994	·916	·851	·794	·740	·691	·648	·610	·576	·540	·511	·484	·457	·434	·412	·392	·310	·251	·209	·176
19										1·790	1·619	1·467	1·351	1·231	1·132	1·049	·967	·899	·838	·781	·730	·684	·644	·608	·570	·540	·511	·483	·458	·435	·414	·327	·265	·220	·186
20											1·704	1·544	1·413	1·296	1·192	1·041	1·018	·946	·882	·832	·768	·720	·678	·640	·600	·568	·538	·508	·482	·458	·436	·344	·279	·232	·196

TABLE IIb.—Cost of Laying One Additional Ton of Copper.

Annual Cost of Electrical Horse-power £	£60	£65	£70	£75	£80	£85	£90	£95	£100	£110	£120	£130	£140	£150	£200	£250	£300	£350	£400	£450	£500
5	·154	·167	·180	·193	·206	·219	·231	·244	·257	·283	·309	·334	·360	·385	·514	·643	·772	·900	1·029	1·157	1·286
6	·231	·251	·270	·289	·309	·328	·347	·366	·386	·424	·463	·501	·540	·579	·771	·964	1·157	1·350	1·543	1·736	1·929
7	·308	·334	·360	·386	·411	·437	·462	·488	·514	·565	·617	·668	·720	·770	1·029	1·286	1·543	1·800	2·057	2·315	2·571
8	·385	·418	·450	·482	·515	·546	·578	·610	·643	·707	·772	·835	·900	·964	1·285	1·607	1·928	2·250	2·572	2·893	3·205
9	·463	·501	·540	·578	·617	·656	·694	·733	·771	·849	·926	1·003	1·080	1·155	1·543	1·928	2·314	2·700	3·086	3·471	3·857
10	·616	·668	·720	·771	·824	·875	·925	·976	1·029	1·131	1·235	1·336	1·440	1·540	2·056	2·571	3·089	3·600	4·115	4·629	5·144
11	·771	·835	·900	·964	1·028	1·093	1·156	1·221	1·285	1·415	1·543	1·671	1·800	1·925	2·572	3·125	3·857	4·500	5·143	5·786	6·430

Percentage allowed for interest and depreciation per annum.	5	7½	10	12½	15	20	25

arrived at the consideration that a square inch and a half for 1,000 amperes is the size we must use, which means a fall of potential of 1·6 volt for each conductor in every 100 yards—that is to say, a fall of nearly 3¼ volts, with the double conductor, for a distance of 100 yards; and whether you like it or not you must have it. It may be met by making distant consumers use lamps requiring a different pressure to those nearer. This is the thing which has given the most trouble, and the point will be considered in the next lectures.

RATIO OF $\frac{\text{AVERAGE}}{\text{MAXIMUM}}$ CURRENT.

n_1	n_2	n_3	n_4	a
0	0	0	1	1·000
0	1	0	1	0·790
1	2	2	1	0·744
1	1	1	1	0·685
2	2	1	1	0·604
0	2	0	1	0·500

I had hoped to have gone a little into a description of systems of laying mains which have been already adopted, but time is pressing too much. I will just say a few words about some of the systems I saw at the Philadelphia Exhibition last year. People seemed to have missed altogether the point that is to be aimed at in underground conductors. There was an invention shown, simply consisting of tiles with holes through them, the cables to go through the holes.

EDISON'S CONDUCTORS.

Outside in inches.	Area of one conductor in circular mills.	Maximum current in amperers.
3·5	1,639,880	1,400
3·0	862,976	760
2·25	262,951	370
1·31	107,289	220
1·05	33,000	100

These are laid in bituminous compounds in iron pipes, and seem to work pretty well for low potential work; but every electrical engineer thinks we shall be able to introduce high potentials some time or other, and reduce the cost of these mains.

What is it that makes it so difficult to insulate these mains properly? It is very difficult to say. It may be that there is a faint leak, and a spark passes to the iron pipe in which the conductors are encased, and that gives rise to an increasing leak. It may be that where there is the faintest leakage there is a partial decomposition of the water that comes into contact with it, and that brings electrolytic action into contact with the insulating material, which we know it generally destroys, and so the leak becomes worse, and very bad indeed. Through the kindness of the Brush Company, I have here a specimen of a fault in one of their underground City conductors showing where it is eaten into. In Philadelphia, there were some systems shown in which there was a very wide trough and glass plates introduced here and there, in which was a large number of holes. Glass is a very bad substance to use; it gets moisture upon it, and, besides, there is a tremendous wasting of space for small wire. In another, copper rods were carried through pipes made as water-tight as possible, supported on rings of glazed porcelain, so that there is a very small surface of leakage possible. With the rings here and there, of course, dampness was a serious obstacle; and in this system it was proposed to blow dry air through the pipes so as to keep the moisture continually out of them. I can only say of this that it is only a proposition; the thing has never been done.

I had hoped to speak to you of what has been done in underground conductors, but really there is very little to tell you, and that can be said in very few words. In Philadelphia, there was a system of underground conductors put down by the Excelsior Company, and they worked pretty well. They used large troughs, and where there are large troughs there is no difficulty about it. But these large troughs had very serious inconveniences that one hardly expected from electricity. Three times during the time I was at Philadelphia the troughs in Chesnut-terrace blew up, a most unexpected result from an electric conductor; but it was a positive fact, and the secret was they were too near the gas mains, which leaked and positively filled the troughs, and, consequently, they blew up when a light came near them. However, these were accidents that might have been prevented with care.

I have an illustration here of the installation at Colchester,* which illustrates the way in which very large troughs are laid with conductors cut along them.

The Jablochkoff Company, on the Thames Embankment has had a lengthened experience, extending since 1878, and with a small 7-16 strand wire, covered with gutta percha and tape, and put in troughs underground, where it has given very little trouble. Then, again, in the City, the Brush Company has had these conductors underground since April, 1880, and they have had a great deal of trouble. They tell me that they were put in first very loosely, and covered with sand for some reason or other, and in drawing the cables through the pipes, the sand wore them away, and the consequence was the insulation went.

Among the most successful underground cables which I have seen are those used by the India Rubber Company, at Silvertown. The cables are numerous, and all made of copper coated with india rubber, with a protecting cover of cold-drawn lead. These are laid in troughs underground, with frequent manholes to assist in the insertion of new cables. Parts of these troughs are always full of water; other parts are always dry; elsewhere there are variations of wetness and dryness. An electromotive force up to 550 volts has been constantly used on most of these cables for several years, and although the insulation has varied with the weather, it has not in a single case been permanently injured, and I am informed that no repairs to the underground cables have been in any case necessary, nor have the manholes been opened except to lay down new cables.

With respect to the printed tables included in this paper, the following rules apply to the second one.

RULES FOR FINDING FROM ANY GIVEN DATA THE SIZE OF THE MAINS REQUIRED.

Data required: Annual cost of electrical horse-power and percentage for interest and depreciation per annum, and cost of laying one additional ton of copper, the approximate size having been assumed.

Rule 1.—In Table II*b*. look down the column of cost for additional ton until you reach the given percentage allowed. Take out the number there indicated.

Rule 2.—In Table II*a*. look along the line with the given cost of horse-power until this number is found. The number at the head of that column is the section per 1,000 amperes in inches.

Rule 3.—If this section be largely at variance with the approximate one selected, use now this value for a second calculation.

* For complete illustrations of this installation we would refer our readers to *The Electrician* for June 21 1884.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. OCT. 14.		BUSINESS DONE WEEK ENDING OCT. 14. Highest.	Lowest.
Anglo-American	30,	31	30	29¾
Do. Preferred	51,	52	52	50¾
Do. Deferred	8,	8¼	8⅝	8¼
Brazilian Submarine	11⅛,	11½	11 3-16	11
Cuba	12,	12½	12⅝	12
Do. Preference	18,	19	18¾	18½
Direct Spanish	1⅛,	2	—	—
Do. Preference	11½	12	—	—
Direct United States Cable	9,	9½	9	—
Eastern Telegraph	11⅛,	11¼	11⅛	11⅛
Do. 6 per Cent. Preference	13⅜,	14½	14½	13⅜
Do. 5 per Cent. Debentures, 1899	105,	108	10½	—
Eastern Extension	12⅜,	13	13	12 11-16
German Union	9½,	9⅝	9⅝	—
Globe Telegraph and Trust	6¾,	7¼	7¼	6 15-16
Do. Preference	13½,	13⅝	13⅝	13½
Great Northern	13⅜,	14¼	14½	13⅜
Indo-European	31,	32	31¾	31½
Reuter's	7⅛,	8	—	—
Submarine	200	210	206	202
West India and Panama	⅛,	⅜	—	—
Do. 1st Preference	8½,	8⅝	8½	—
Western Brazilian	5⅞,	6	—	—
Western Union 7 per Cent. 1st Mortgage	120,	124	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	13-16,	15-16	⅞	—
Oriental	½,	⅝	—	—
United Telephone	11½,	12	11 15-16	11 13 16

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1⅞,	2¼	—	—
Do. (fully paid)	3½,	4	—	—
Hammond Light (£3 15s. paid)	1-16	3-16	—	—
Swan	⅛,	⅜	—	—
Maxim-Weston	3-16,	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	36,	37	36¾	35¼
India Rubber, Gutta Percha, and Telegraph Works	23½,	24½	24½	23

TRAFFIC RECEIPTS FOR SEPTEMBER, 1885.

COMPANIES.	Sept., 1885.	Sept., 1884.	Increase.	Decrease.
Brazilian Submarine	—	—	—	—
Cuba Submarine	2,100	2,163	—	63
Direct Spanish Telegraph	1,770	1,663	107	—
Eastern Telegraph	47,849	50,913	—	3,064
Eastern Extension	41,845	41,590	255	—
Great Northern	25,200	—	—	—
West Coast of America	3,680	—	—	—
Western and Brazilian	—	—	—	—

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NOTES.

PERSONAL.—Major Bagnold, of the Royal Engineers, has assumed charge of the British military telephone system in Cairo.

H.M.S. "IMPERIEUSE."—It is proposed to equip this vessel with three engines for driving the Siemens' dynamos to be used in the lighting of the ship.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 16th inst. amounted to £3,424.

OVERHEAD WIRES IN AMERICA.—There is a telegraph pole in Fulton-street, New York, upon which 300 telegraph wires, going in all directions, are said to be strung.

THE ATLANTIC CABLES.—According to the latest intelligence the steamer "Faraday" has picked up one end of the broken Mackay-Bennett cable. It is likely to be restored in a few days.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th October are £1,963, as compared with £1,718 in the corresponding period of 1884.

THE ELECTRIC LIGHT ON RAILWAYS.—The Lancashire and Yorkshire Railway are still experimenting with the electric light for the lighting of their carriages, but will not be able to come to any conclusion on the matter in time for the coming winter.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 16th October, were £2,690, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

APPOINTMENT.—Mr. Henry Stott for three years an electrical engineering student at the Glasgow College of Science and Art has been appointed assistant electrician on board the Anglo-American Telegraph Company's repairing steamer "Minia," now stationed at Halifax.

EARTHQUAKE AT PALERMO.—A telegram from Palermo announces that a shock of earthquake occurred there on the morning of the 15th inst. A house, three stories high, in the Via Santa Rosalia, fell in, and a number of persons were buried in the *débris*. Eight bodies have been recovered.

THE TELEPHONE IN BRESCIA.—The Kinetic Engineering Company inform us that the telephone company of Brescia are now placing the whole of their system of telephone wires underground by means of the Berthoud-Borel cable, and have taken delivery of 106 miles of conductors for that purpose.

"HAYDN'S DICTIONARY OF DATES."—We have received from Messrs. Ward, Lock, and Co. a specimen sheet of this high-class popular record. It is the latest edition, brought down to the summer of the present year, and may with truth be said to be the most universal book of reference of its kind.

THE JOHN PENDER GOLD MEDAL.—This medal has been gained by H. Osbourne Bennie Whitworth, scholar and Royal Exhibitioner. Mr. Pender again offers a similar medal to be competed for by students taking the diploma this session in electrical engineering at the Glasgow College of Science and Arts.

AN AMERICAN CONTRACT OPEN.—Tenders will be received until November 5th by the War Department, Washington, D.C., for furnishing 1,050 galvanised iron telegraph poles (with foot-supports and cross-arms) complete, 2,100 wooden insulator plugs, and 70 miles No. 9 galvanised iron telegraph wire.

L'EXPOSITION DU TRAVAIL, PARIS.—The jury of the electrical section of this Exhibition commenced its labours on the 10th inst. It is composed of MM. Bourdin, of *La Lumière Electrique*, president; Hospitalier, of *l'Electricien*, reporting secretary; Armengaud, Boivin, Gariant, and Mildé, members.

AERIAL NAVIGATION.—In view of the successful experiments in aerial navigation by means of electricity carried out by Captains Krebs and Renard at the Chalais-Meudon Park, the French Minister for War has decided to ask for a special credit for the purpose of continuing the experiments on a larger scale.

OMINOUS.—The Western Union Telegraph Company are said to be importing a number of low salaried operators from the Canadian provinces for service in Eastern offices, and it is supposed by some that this is a note of preparation for the rate competition with rival lines which for some time has been on the *tapis*.

NOTICE OF INTERRUPTION.—The Direct Spanish Telegraph Company, in notifying the interruption of both of their Falmouth-Bilbao cables, inform us that arrangements have been made by which telegrams for Bilbao, Madrid, and other places in Spain can, during the interruption, be promptly forwarded by the Eastern Telegraph Company's route.

BUSINESS NOTICE.—We hear that Messrs. Walter T. Glover and Co., of Manchester, the electrical wire and cable makers, contemplate placing their business on the limited liability company basis, but that only a small amount of additional capital will be available for the personal or business friends of the firm, the concern becoming what is generally termed a private "limited."

THE EDINBURGH EXHIBITION.—Particulars will be found in our advertisement columns of the International Exhibition of Industry, Science, and Art, to be opened in Edinburgh next year. This Exhibition will be open to the products, manufactures, &c., of all countries, and should, if its list of patrons be taken as a criterion, be one of the most perfect things of its kind we have seen.

A PROGRESSIVE PEOPLE.—While at Bergen Mr. Gladstone is said to have been particularly struck by the fact that in a town with a population not exceeding 50,000, there are not fewer than 500 subscribers to the telephone, and that between three and four thousand townspeople have already subscribed to a project for substituting electric lighting for gas in private houses and in the streets.

CHEAP TELEGRAMS AND REGISTERED ADDRESSES.—A correspondent writes as follows to *The Times*:—"In order to facilitate the transmission of telegrams, I would suggest that the authorities should issue periodically a complete alphapetical list of registered names and addresses, giving the corresponding 'indicators.' This would greatly add to the usefulness of the new system."

AN IMPORTANT SALE.—The important sale of the plant belonging to the Hammond Company, now being conducted by Messrs. Wheatley Kirk, Price, and Goulty, is deserving of notice. Full particulars of the auction will be found in our advertisement columns, and we strongly recommend those of our readers whose tastes or business considerations warrant them in doing so to pay the sale a visit.

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THE ELECTRIC LIGHT IN CANADA.—The promenade known as the Dufferin-terrace, Quebec, has recently been lighted with electric lights. The power for generating the electricity is supplied by the Falls of Montmorency (some nine miles distant), which give a strength equal to about 1,600 horse-power. The experiments have been satisfactory and successful, and the question of lighting the entire city in a similar manner is now under consideration.

THE FREEMAN INCANDESCENT LAMP.—The incandescent lamp recently invented by Mr. W. P. Freeman, of New York, possesses some novel features. The carbon is a straight thread, which is supported by a thin glass rod bent at the top. This allows the length of the carbons to be regulated so as to be of uniform resistance, and the distribution of light in the plane perpendicular to the lamp is equal in all directions. The cost of the lamp is also claimed to be considerably decreased by this method of construction.

ELECTRIC MACHINERY IN AMERICA.—The applications of electricity to trade purposes are continually increasing in America. Amongst others, the Wiswell Electric Machinery Company has erected a number of pulverising mills at different mines in that country. The work done has been quite satisfactory, and in a number of instances additional mills have been ordered. A number of certificates of the work done have been published by the company, and are of interest to proposing purchasers. This looks rosy enough.

THE EDISON LIGHT IN BELGIUM.—We are informed that the Compagnie Edison de Paris are about to concede to the Société Anonyme du Phœnix, at Ghent, an exclusive right to the exploitation in Belgium of the Edison system for the generation and maintenance of the incandescent light, and the transmission of power. The Société Phœnix have already installed 1,200 lamps in the important manufactory of M. Ferd. Lousbergs, at Ghent, an experiment which, as gas is very cheap in that place, is being watched with great interest.

PUZZLED.—The American papers revel in stories about the English operator. Here is the latest:—"Won't you please rush that," said an American, as he handed a despatch to a telegraph operator in a little town near London. The operator looked up with a blank expression. "Won't you rush that despatch, please?" repeated the gentleman. The look of amazement on the operator's face deepened. "Won't you send that just as quickly as you can?" the American explained. "Oh, yes," exclaimed the relieved operator; "just as soon as you get the stamp on."

ANOTHER CELL.—Prof. Dolbear has discovered that if zinc be immersed in a saturated solution of ammonium chloride in a porous cup, and carbon in a saturated solution of bichromate of potash, mixed with sulphuric acid, the E.M.F. of the combination is 1·1 volt. The internal resistance of such a cell, with a simple zinc rod such as that used in the Leclanché, and the carbon plate 6in. by 2in., is less than 0·5ω. Its constancy is said to be such that if kept on short circuit (through 4ω or 5ω) it does not fall in strength to any appreciable degree. If the bichromate solution be mixed with strong nitric instead of sulphuric acid the E.M.F. rises to 2·3 volts.

HOW IT CAME ABOUT.—According to a letter written to an American contemporary, when Professor Morse was engaged in the slow and tedious process of laying his first telegraph wire underground between Washington and Baltimore, a sudden shower compelled him to seek shelter under a bridge. While waiting there, he remarked to his son Charles, that "when it was first proposed to use glass window panes in England, it was strongly objected to as impracticable on account of the risk of their being smashed. Glass was used," continued the professor, "and from here on I mean to string my wire on poles and take the risk." And henceforth poles were used.

THE ELECTRIC LIGHT IN THE TEMPLE.—The arrangements for illuminating the Inner Temple Library with the electric light are now completed. The testing experiments will shortly be made, and it is anticipated that all will be in readiness for lighting the library by electricity tomorrow, when the regular opening of the library for the Michelmas sittings will be resumed. A new engine house has been erected adjacent to the Inner Temple Lecture Hall, in King's Bench-walk, and a 12 horse-power engine for generating the electric light has been placed therein. The Swan-Edison system is the one adopted, and about 130 small lamps will be employed for illuminating the library.

THE ELECTRIC LIGHT AND THE CHELSEA VESTRY BOARD.—At a recent meeting of this Board the Electric Lighting Committee reported, recommending that the clerk be authorised to reply to the Chelsea Electricity Supply Company that the vestry will view with approbation any proposal to light the district with electricity, and that, provided the terms of the provisional order be satisfactory, the vestry will support it. Also that the South Kensington District and Electricity Lighting Company be informed that as soon as the applicants have obtained the necessary statutory authority to supply the electric light in this parish the vestry will be prepared to entertain the proposal. This was adopted.

THE CITY AND GUILDS OF LONDON INSTITUTE.—At a meeting of the executive committee of this institute, held on Monday, the following letter from the Prince of Wales was read:—"Sir: Believing that the Right Hon. Sir R. N. Fowler, Bart, M.P., Lord Mayor, is able and willing to render efficient service to the City and Guilds of London Institute for the advancement of technical education, I have great pleasure in the exercise of the powers conferred upon the president by the articles of association in nominating him for a period of five years vice-president of the institute.—I am, sir, yours faithfully, ALBERT EDWARD. Philip Magnus, Esq., Director and Secretary of the City and Guilds of London Institute."

A FAILURE PREDICTED.—So far everything has worked well with the installation in the Theatre Royal at Bucharest. On the 10th instant the theatrical season commenced, and according to the terms of their contract with the Société du Gaz de Bucharest, the company whom M. Jehl represents, were to operate the plant to the end of the third representation and then to hand it over to the gas company. This has been done, and the gas people are now responsible for its working, the Société Electrique Edison de Paris having nothing more to do with it. This latter fact seems to require mention in that a new gas director at Bucharest, who has the control of affairs in his own hands, is said to be strongly prejudiced against and inimical to the electric light, and it is felt in well-informed circles that a breakdown is somthing more than probable. It may be added that the gas company have their own electrician in charge of the installation.

ELECTRIC LIGHT FOR WAR SHIPS.—Messrs. Goolden and Trotter have received orders to supply the machinery and fittings for the two latest additions to the navy, viz., the "Mersey" and the sister ship "Severn." The dynamos will be of the sizes known as 40 and 20 units, there being one of

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each of these in each ship. The Admiralty rules require very low speeds for driving electric machinery, which necessitates very large and heavy machines. Each pair of dynamos will weigh about 3½ tons, and running at their ordinary speed, would light 2,400 electric lamps of 10 candle-power each. Messrs. Goolden and Trotter have been engaged for some weeks in fitting the well-known ironclad "Devastation" with the electric light. This ship presents great difficulties on account of its unusual shape. It is fitted with incandescent lamps with mountings, which have also been made by the same firm, together with two powerful search lights.

SUGAR MADE BY ELECTRICITY.—The synthesis of saccharose having been accomplished by Messrs. Aubert and Giraud, it is anticipated, says a contemporary, that the discovery may prove most important to the sugar industry. Amylaceous matter obtained from the potato, having been converted into glucose in the usual manner, is submitted to the action of an electric current equal to about seventy-five volts. The electrodes were immersed in the solution, and the current reversed from time to time. In about two hours the reaction terminated, as indicated by the liquid no longer giving the characteristic colour with tincture of iodine or a precipitate with alcohol. The liquid was then defecated with lime, which was subsequently removed by carbonic anhydride, and the syrup was decolourised and crystallised. On analysis it yielded 88·38 per cent. of saccharose, but was far from being cane sugar. It is questionable whether the reaction consists in the dehydration of glucose, the union of a molecule of dextrine with one of glucose, or the hydration of dextrine.

THE MAGNETIC UMBRELLA.—With reference to the umbrella of a passenger which recently affected the compass of the steamer "Princess Beatrice," when crossing between Belfast and Stranraer, the captain of the vessel has received a letter from Mr. Bottomley, assistant at Glasgow University to Sir William Thomson, stating that Sir William has examined the umbrella and found it powerfully magnetised. Sir William Thomson thinks it probable that the steel ribs of the umbrella have been magnetised through being brought near to a powerful dynamo when at work. The umbrella was so powerfully magnetised that it would produce a very considerable effect on the compass if brought near it. Sir William desires to add that, in these days, when electric lighting is becoming so common, and when anyone, without knowing it, may get the steel ribs of his umbrella magnetised by going near to dynamo machines, he thinks it of great importance that steps should be taken to prevent passengers on vessels with umbrellas going near the compass in use. Mr. Bottomley also states that he has known the rim of his hat to slightly disturb the compass of a vessel.

TELEPHONING FROM LIGHTSHIPS.—The following letter has been written to *The Times*:—"The Elder Brethren of the Trinity House, observing the notice in *The Times* respecting the progress made in establishing electric communication between the Sunk Lght Vessel and the shore, will be glad if you will enable them to prevent possible misapprehension on the part of the shipping community by stating the following particulars:—The Telegraph Construction Company have undertaken for a certain sum to maintain the communication for twelve months as an experiment. They have met with many difficulties, occasioning interruptions, sometimes of a few hours, at other times a day or two. Communication ceased on the 2nd inst., and has not yet been restored; but the company are still hopeful of complete success. But this corporation have not undertaken, nor authorised the company to undertake, to signal passing ships to Lloyd's or to convey orders to them. The experiment is being made with the consent of the Board of Trade, under conditions which involve, perhaps, considerable expense to the Mercantile Marine Fund, and no individual or association has the privilege of receiving intelligence or giving instructions by this means at the expense of that fund."

SOUTH STAFFORDSHIRE MILL AND FORGE MANAGERS' ASSOCIATION.—A monthly meeting of this institute was held recently in the Geological Museum, Dudley, Mr. R. S. Casson presiding. Mr. Arthur Edgar Cotterell (Birmingham) read a paper on "The Development of Telephony." The reader traced the earliest efforts of inventors in the direction of telephony to the systems of the present day. He paid special attention to Prof. Bell's efforts, and said it was due to him that the telephone had become a permanent industry, and one calculated to change many of the social aspects of the countries in which telephony was adopted. The instrument was clearly described, and then the reader went on to the inventions of Edison, who, by the introduction of an improved microphone, enabled one person to speak to another fifty miles away with no more exertion than was needed for fifty yards. The loud-speaking telephone, used for exhibition but not for business, was also described. Mr. Cotterell then described and worked a Bell-and-Blake combination machine, and said he believed the National Telephone Company was about to start a branch in the town. The reader finally discussed the progress made by the company in the past six years, and the work of a telephonic exchange. A hearty vote of thanks to Mr. Cotterell concluded the proceedings.

INFLUENCE OF STORMS ON SUBTERRANEAN TELEGRAPH LINES.—When the construction of the long subterranean lines in France was commenced some years ago, it was thought that their conductors would be quite free from the effect of storms. Accidents are much rarer than with aërial lines, but that they do occur was evidenced by the violent storm on the 9th March at the middle of the underground line connecting Belfort with Besançon, when sparks appeared at the two extreme stations. This phenomenon, apparently contrary to the theory of static electricity, M. Blavier thinks may be explained either as an effect of electro dynamic induction or as an effect of electrostatic induction. If the cable is buried only to a small depth in a badly-conducting earth, the sheathing takes, under the influence of storm clouds whilst the internal wire remains neutral, a more or less considerable electric charge. At the discharge of the clouds this charge becomes free, and escapes into the earth, following the sheathing in two opposite directions. This will develop in the interior conductor two induced currents of contrary directions, the difference of which will act on the apparatus at the end stations. Or the conductor may charge itself from the earth-plates and lightning-guards under the influence of this sheathing charge.—*Abstracts, Proc. Institution of Civil Engineers.*

DETERMINATION OF DEATH BY MEANS OF ELECTRICITY.—This idea, far from being new, is one of those that were early suggested in the minds of physicians in the application of the electric current for the cure of disease. It would naturally be supposed that the current might serve to indicate the presence of death by some specific difference in the nature or intensity of the muscular contractions. But experiment demonstrated that generally the muscular contraction under the stimulus of electricity was, for three or four hours after death, exactly the same as in life. For this reason electricity was abandoned as a method of proving death. But the question has again been brought forward by some recent experiment by Dr. Buch. This observer has shown (1) that the temperature is

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sensibly increased during life at the surface of the muscle exposed to the action of the electric current; (2) that this increase of temperature is never produced upon the dead body, even immediately after death, and while the muscular contractibility is still perfect. This should afford an absolutely sure proof of death. Dr. Buch, in his experiments, makes use of an ordinary mercurial thermometer, simply applied to the surface of the skin. He waits until this thermometer shows the temperature of the surrounding medium, and then submits the subjacent muscle to the current of induction. The temperature of the skin increases several degrees under the influence of an energetic contraction. This phenomenon is constant during life, even in cases of complete paralysis of the part. On the other hand, in the dead body, whatever may be the force of the current and the violence of the contraction, the mercury remains stationary in the tube.—*Electrical World.*

Railway Carriage Lighting.—The following letter from "Another Railway Traveller" appeared in *The Times* of the 10th instant, in reply to one written asking for more light in the carriages and adversely criticising the action of the company in giving such a good light at the Paddington station:—"I trust you will allow me to make some remarks in reply to certain injurious observations in a letter under the above heading, which appeared in *The Times* of Friday, regarding the great electric lighting undertaken by the Telegraph Construction and Maintenance Company at Paddington. This is the greatest experiment which has yet been tried in England, and I believe also there is no equally large installation from a single centre even in the American towns, which are so far ahead of us in electric lighting. Your correspondent, as a constant traveller, should know enough of the Great Western management to feel sure that they were only accepting it on proof that it would show a reduction in the very heavy cost of the present gas lighting there, and he is certainly not justified in imputing that the directors are allowing it as an advertisement for the benefit of the Telegraph Construction Company, which is, I hope, too well known and stands too high to require any such advertisement. The company is the only company which have retained their license for lighting up part of London under the provisions of Mr. Chamberlain's Bill. As that quarter of London which is included in their order contains all the chief London clubs, there are few of us who will not benefit by the great success of the experiment. I think, therefore, the severe remarks of your correspondent were hardly justified. Your correspondent is equally in error in stating that the electric lighting of the carriages is out of the question on account of the great expense. It is found to be such an economy that before the end of the year it will, I learn, be largely adopted, to, I hope, our great additional comfort."

The Telegraphists' School of Science.—The tenth annual session of this school, for the operators at the Central Telegraph Office, St. Martin's-le-Grand, commenced recently. Mr. W. Slingo is lecturer, and the school is in connection with the Science and Art Department, South Kensington, and the City and Guilds of London Technical Institute. The accompanying list of prizes and certificates awarded to last session's students will give some idea of the range of study offered to the rising telegraphists. Results of science and art examinations: Mathematics — Certificates: 1st class, Messrs. Brooker and Honeysett; 2nd class, Mr. F. W. Butler; advanced, Mr. Mansbridge. Chemistry—Certificates: 1st class, Messrs. H. S. Beach and Honeysett; 2nd class, Messrs. Bennett, W. G. Franks, Honnor, Pace, Philpott, Senhenn, and Winn. Magnetism and Electricity—Certificates: 1st class, Messrs. Beach, Bell, Connell, Cooper, Honnor, Knight, Mason, and Waller; 2nd class, Messrs. G. Barnett, Miles, Neasmith, Offord, and Twyford. Magnetism and Electricity (advanced stage)—Certificates: 1st class, and Queen's prizes, Messrs. F. W. Butler and Mansbridge; 2nd class, Messrs. Bennett, Crabtree, W. G. Franks, Honeysett, McSweeney, Pace, Philpott, and Strank. Results of City and Guilds Institute Examination:—Telegraphy—Bronze medal, £5 prize, and 1st class honours certificate, Mr. Mansbridge; bronze medal, £3 prize, and 1st class certificate, Mr. Brooker; 1st class certificate, Mr. F. W. Butler; 2nd class certificates, Messrs. G. T. Bennett, Philpott, and Winn; honours certificates, Messrs. W. H. Butler, Beach, Hendri, and Connell. The above were supplemented with what are known as the local prizes, twenty-six in number, the first aggregate, or controller's prize, going to Mr. Mansbridge; the second, or sub-controller's to Mr. F. W. Butler; the third, or committee's prize, to Mr. H. S. Beach; the fourth, or engineering superintendent's prize, to Mr. Brooker.

Cornell University.—For the last two years the greater part of the additions to the physical apparatus at the Cornell University for the study of electrical science and electrical engineering have been instruments for study and investigation in electrical science or its applications. An instrument has been constructed during the last year, for the absolute measurement of electric currents of all values from a milliampere to 250 amperes. It is believed to be larger, and to have a wider range than any other standard instrument in existence. It has been constructed with the utmost care, and is capable of giving results of the highest precision. The building in which it is placed contains also several other instruments for the measurement of currents, potentials, magnetic intensity, &c., and the physical laboratory with which it is connected contains five dynamos from which currents may be obtained up to 50 amperes at 100 volts, or up to 20 amperes at 1,000 volts. A resistance of about seven miles of No. 16 German silver wire in about 100 sections, capable of combinations to give resistances from less than half an ohm to 2,200 ohms serves for controlling dynamo currents. A steam engine of about 30 horse-power, having a governor of the most perfect type, will soon be in place for driving dynamos. Dynamometers, &c., are provided for measuring power, and, in fact, all the instruments are at hand that can be required for the measurement of any quantity connected with the use of electric currents for electric lighting. With the arrangements provided, currents of great uniformity and of any strength desired are available for purposes of experiment and investigation. These instruments are not only seen, but are in constant use by students, who, when they are sufficiently advanced, are encouraged to undertake some investigation of scientific or practical value. It is the aim of the course in electrical engineering as here taught to give to the student a thorough mathematical training and a full knowledge of the theory of electricity as a basis of the practical work that is to follow. Drawing and the theory and construction of machines and motors are taught as essential to the success of any electrical engineer. The course requires four years for its completion, and is very comprehensive.

The Telephone in Carlisle.—The National Telephone Company recently inaugurated the practical working of the wires which they have erected in this city and district. The mayor, several members of the corporation, the corporation officials, and a number of other gentlemen interested in the undertaking, attended at the central office of the company in Devonshire-street. The wires between Carlisle and Dalston were then joined up, and commenced to work.—The Mayor

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then declared the Telephone Exchange open, and in a few complimentary remarks wished the undertaking success.—Mr. A. R. Bennett, general manager, gave some explanations as to what the company were doing and intended to do in Carlisle and the neighbourhood. The subscribers already numbered 26. The corporation had 10 connections between their various departments. The company had opened three call offices, which were places where subscribers who happened to be passing could go into and use the telephone for the purpose of speaking to any other subscriber. One of these was at the chief bookstall at the railway station. The benefits of the call offices were not confined to subscribers. Any member of the public having occasion to communicate with a subscriber would be allowed to do so by going to a call office and paying threepence for each three minutes' conversation in telephone stamps, which were on sale at all the call offices. He called attention to the great facilities offered by the Exchange for conveying alarms of fire. Some towns had gone so far as to connect the police office with the house of each individual fireman, and to place loud-sounding bells over each man's bed. Something of the same kind would, no doubt, be ultimately adopted in Carlisle, but in the meantime the new connections for the fire and escape stations were far in advance of the old system. The company had opened during the present year exchanges in Maryport, Workington, Whitehaven, Cleator Moor, and Frizington, and joined all these towns together, and as support was forthcoming they would work north from Maryport and south from Carlisle until the two systems were connected. In Yorkshire the company had connected Bradford, Leeds, Sheffield, and many other towns together; in Scotland their system was continuous from Greenock to Edinburgh, a distance of seventy miles; and from Perth to Dundee, Forfar, and Arbroath. Everywhere the lines were extending, and the day was close at hand when the different sections, at present isolated, would meet, and the telephonic system would be co-extensive with that of the telegraph.

THE LIGHTING OF THE CITY.—In an interesting article upon the electric light the *City Press* says :—" There are some mysteries in the proceedings of the Commissioners of Sewers that seem quite incomprehensible. The handsome Holborn Viaduct was lighted with electricity for some time, with great satisfaction to everybody; it was suddenly changed back to the old dismal gas, nobody knows why. Many of the shops on each side of the way are still lighted with electricity, so the only possible reason for the change in regard to the public lamps must be the question of expense. This is, of course, a matter of importance, but it all depends on the question of degree. We were informed last week, on such authority as we cannot doubt, that this same Holborn Viaduct could be relighted with electricity, giving double the present amount of light, at an extra expense of some £400 per annum. Surely this amount cannot be considered prohibitory. We have heard the calculation made that the whole City might be lighted with electricity, producing double the amount of light now, not enjoyed, but endured, at an additional expense of less than one halfpenny in the pound in the consolidated rate. When we remember that the cost of the new street at Billingsgate, which can only possibly be of advantage to the immediate neighbourhood, if really of advantage there, represents, we are told, an addition to the rates of not less than twopence in the pound for at least twenty years, or four times the price estimated for doubling the present lighting of the City, we can but wonder at the ignorance displayed by some public men in the science of proportion. The great mistake seems to be in waiting for some plan to be discovered that will enable the Commissioners to simultaneously light the whole City without the possibility of any temporary failure. But this is really something like putting off any advantage from this wonderful discovery for an absolutely indefinite period. What is wanted is a series of experiments on a sufficiently large scale to be a fair test of efficiency; and if this be done under the able superintendence of any of those men who have made electricity their study, and have demonstrated what brilliant results can be obtained from its use, we have but little doubt that in a very short time such an improvement will be witnessed in our street lighting as will not only gratify all who have to use our streets after dark, but will also afford to our excellent police that increased facility in carrying out their arduous and important duties that we are told, and thoroughly believe, can be obtained by no other means."

CONTINENTAL NOTES.—The development of the electric lighting industry in France has been, in comparison with other Continental countries, but slow and uncertain. In Germany, on the other hand, such rapid strides have been made that it has been found necessary to formulate statistics for the information of the people. In Berlin at present there are in all 41 arc and 31 incandescent lamp installations, of which 25 are actuated by gas and 46 by steam engines. The number of lamps is not indicated, but it is believed not to exceed 5,000. Two central stations, each capable of alimenting 7,500 incandescents, are, however, in course of construction. At Munich there are 34 installations, comprising 140 arc and 4,045 incandescent lamps. The principal theatres and the Central Railway Station are the establishments which up to now have adopted the new illuminant. Hamburg has not more than 25 installations, with a total of about 80 arcs and 1,400 incandescents. Five of these installations, with 25 arcs and 200 incandescents, are worked by gas engines, whilst the more important or larger ones employ steam power. At Hanover the station entrance is lighted by 12 arc lamps, the Jardin des Palmièrs by 8 arc lamps, and 10 others of the same kind are installed in two of the streets. Hanover does not as yet possess a single incandescent lamp. Bremen possesses but two arc installations, *i.e.*, at the public baths and the Bureau de la Caisse d'epargne. In the first of these the dynamo is driven by steam, and in the second by gas power. At Cologne there are 8 arcs and about 400 incandescents. At Leipsig three cafés dansant, three manufactories, and one electric store are lighted by electricity. Dresden has 14 installations, comprising together 62 arcs and 446 incandescents. Of these ten are in manufactories possessing steam power, and four are driven by gas engines. At Breslau the electric light has not made much progress. A few restaurants and shops only are so lit. Amongst the industrial villages, however, the new illuminant has found more extensive application, principally, of course, in the manufactories. Chemnitz has seventeen installations distributed among various establishments, and including 117 arc and 470 incandescent lamps, actuated in the majority of cases by existing steam plant. Crefeld has 69 arcs and 1,203 incandescents, about half of them being driven from steam and the other half from gas engines. At Barmen there are fourteen installations, having 81 arcs and 630 incandescents in the different factories. Elberfeld possesses seven installations, with nine arcs and 126 incandescents. Gladbach has 15 arcs and 230 incandescents, driven as in former instances by the steam engines used in the establishments for business purposes. In other towns in Germany there are isolated installations. Dr. Schilling estimates the actual number of installations in German towns at about 400, comprising approximately 1,500 arc and not less than 20,000 incandescent lamps.

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THE DETERMINATION OF CURRENTS AND RESISTANCE IN A NETWORK OF CONDUCTORS.

In the larger "Treatise on Electricity and Magnetism," by Professor Clerk Maxwell, we find given a solution of the general problem of determining the distribution of currents in any system of conductors, containing any sources of electromotive force, whatever may be the form of the network. Maxwell does not, however, give any *general* method whereby we may determine the *resistance* between any two points upon such a network, when the resistance of each separate branch is known. This latter problem has recently been investigated by Dr. Fleming, and in a paper read before the Physical Society he has shown that by means of a development of Maxwell's method we may calculate, not merely the final distribution of current and the steady resistance between any two points of a network, but we may also take account of the time variation when there is self or mutual induction between the two branches, or when the current arises from a condenser discharge. It will thus be seen that Dr. Fleming's paper is one of very considerable interest and value, and it will well repay careful study.

We propose at this time to give the substance of that portion of the paper relating to the determination of currents and resistances, which is of the more immediate and general importance. We shall confine ourselves principally to a statement of the results which are arrived at, leaving those who wish for the demonstration of the methods to consult the original paper.

We will take first Professor Clerk Maxwell's solution of the problem of determining the distribution of current in a network of conductors. The process employed will, perhaps, be most easily explained if we work out a case in illustration.

Let Fig. 1 represent a network of conductors (the form being of course indifferent); let the resistances of the separate conductors A, B, C, D, E, F, G be known; let there be sources of electromotive force e_1 and e_2 acting in the branches B and G respectively, and let these E.M.F.'s be directed as indicated in the figure. It is required to determine the distribution and direction of the currents throughout the system.

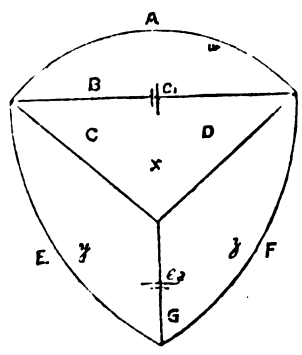

FIG. 1.

First, suppose that around each mesh or cell of the network an imaginary current circulates, always in the positive direction; that is, in the direction opposite to that of the hands of a watch. Let w, x, y, z denote these imaginary currents. Then it is easy to see that any conductor which forms a boundary between any two adjacent meshes is necessarily traversed in *opposite* directions by the imaginary currents belonging to the meshes upon either side of it. Then the *real* currents in the conductors will be found by taking the differences of the imaginary currents which we attribute to the meshes which they bound. For instance, in Fig. 1, going around the boundaries of mesh x we shall have the following values for the actual currents:—The current in branch B will be denoted by $(w-x)$, that in branch C by $(y-x)$, and that in branch D by $(y-x)$. The x, y, z, &c., are called the cyclic symbols of the areas in which they are placed; the cyclic symbol of external space being taken as zero. Now, as the real currents must all be of positive sign, it will be seen that when we know the values of the cyclic symbols we can immediately state the *direction* of the current in any branch.

To obtain these values we have now to form an equation for each cycle or mesh. For the case represented in Fig. 1 we shall have the following set of equations, beginning with the mesh at the top:—

$$\begin{aligned} e_1 &= w\overline{A+B} - xB - yO - zO \\ -e_1 &= x\overline{B+C+D} - yC - zD - wB \\ e_2 &= y\overline{C+E+G} - zG - wO - xC \\ -e_2 &= z\overline{D+F+G} - wO - xD - yG \end{aligned}$$

These equations may each be formed according to the following rule:—Write as the coefficient of the cyclic symbol the sum of all the resistances which bound that cycle, and subtract the cyclic symbol of each adjacent cycle, multiplied respectively by the common bounding resistance as coefficient, and equate this to the effective electromotive force acting in the cycle, written as positive or negative according as it acts with or against the imaginary current in the cycle. If there is no electromotive force acting in any conductor bounding the cycle, the expression is equated to zero. For a reason which will presently appear, the cyclic symbols of non-adjacent meshes are written down in order with zero coefficients.

In this way we can form as many independent equations as there are cyles, and by the solution of these we may determine each of the independent variables, x, y, z, &c. And, finally, we obtain the magnitude and direction of the real currents in any of the conductors by taking the difference of the values of the cyclic symbols for the meshes adjacent to it. In order to save labour whenever the current in one branch only is required, Maxwell writes the cyclic symbol upon one side of the branch equal to $(x+y)$ and upon the other side equal to y, and then the real current in the branch will be $x+y-y=x$. In this way, by a simple re-arrangement of the network equations, we have only to complete the solution for one variable. Dr. Fleming points out that the solution of the set of simultaneous equations thus obtained is much facilitated by employing the method of determinants. It can easily be shown that if there are n linear equations of the type

$$\begin{aligned} a_1x_1 + a_2x_2 + \ldots\ldots a_nx_n &= p_1 \\ b_1x_1 + b_2x_2 + \ldots\ldots b_nx_n &= p_2 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ k_1x_1 + k_2x_2 + \ldots\ldots k_nx_n &= p_n \end{aligned}$$

The solution for any variable x_1 is the quotient of the determinants.

$$x_1 = \frac{\begin{vmatrix} p_1 & a_2 & \ldots & a_n \\ p_2 & b_2 & \ldots & b_n \\ \ldots & \ldots & \ldots & \ldots \\ p_n & k_2 & \ldots & k_n \end{vmatrix}}{\begin{vmatrix} a_1 & a_2 & \ldots & a_n \\ b_1 & b_2 & \ldots & b_n \\ \ldots & \ldots & \ldots & \ldots \\ k_1 & k_2 & \ldots & k_n \end{vmatrix}}$$

The rule by which these two determinants are formed will be obvious on inspection, the denominator being constant for each variable. When the numerical values of the terms are known the evolution of a determinant of any order reduces itself to the successive application of the elementary rules of arithmetic.

As a simple case of the use of this method let us employ it to investigate the conditions which are required to obtain a balance in the Wheatstone bridge as ordinarily employed to measure a resistance.

We have six conductors connected together so as to produce three cells or meshes. Writing $\overline{x+y}$, y and z for the three cyclic symbols, E for the E.M.F. of the battery, and taking the

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resistances as lettered in the figure, we obtain for the cyclic equation

$$E = z(\rho + c + d) - yd - \overline{x+y}\,c$$
$$0 = y(d + b + g) - zd - \overline{x+y}\,g$$
$$0 = \overline{x+y}(a + c + g) - zc - yg$$

Rearranging we obtain

$$E = -xc - y(c+d) + z(\rho + c + d)$$
$$0 = -xg + y(b+d) - zd$$
$$0 = x(a+c+g) + y(a+c) - zc$$

Solving for x we get the determinant equation

$$x = \frac{\begin{vmatrix} E. & \overline{c+d} & \overline{\rho+c+d} \\ 0 & \overline{b+d} & -d \\ 0 & \overline{a+c} & -c \end{vmatrix}}{\Delta}$$

where Δ stands for the determinant forming the denominator,

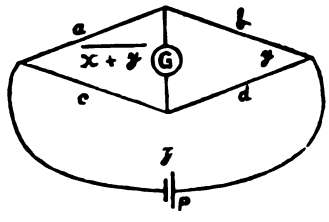

Fig. 2.

whose specific value we shall not require. This expression reduces at once to a second order determinant

$$x\Delta = E \begin{vmatrix} b & -d \\ a & -c \end{vmatrix}$$

or $x\Delta = E(ad - bc)$.

In this expression if we put x equal to zero we obtain the known relation

$$a : b :: c : d$$

Whenever the branch for which we have to find the current forms a part of the external boundary of the figure, we shall evidently have $(x - 0)$ for the real current; so that some additional trouble is saved by taking care to arrange the figure in this way whenever it is possible to do so.

As a further illustration, consider Poggendorff's method of comparing the electromotive force of cells. The required connections may be drawn as in Fig. 3.

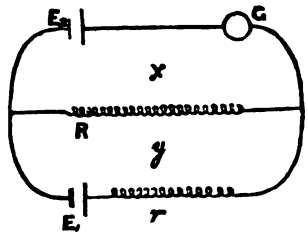

Fig. 3.

E_1 represents the E.M.F. of the standard, and E_2 that of the trial battery, R and r are the adjustable resistances. To determine the conditions which establish equilibrium in the galvanometer, that branch being a part of the external boundary, we write x (only) for its adjacent cyclic symbol, and y for the symbol belonging to the other mesh. The cylic equations are

$$-E_2 = x\overline{G+r} - yR$$
$$E_1 = -xR + y\overline{R+r}$$

from which

$$x\Delta = \begin{vmatrix} -E_2 & -R \\ E_1 & \overline{R+r} \end{vmatrix}$$
$$= E_1 R - E_2(R + r)$$

which, when x is made equal to zero, gives for the required condition

$$E_1 : E_2 :: R + r : r.$$

We proceed now to Dr. Fleming's method for obtaining the resistance of a network between any two given points. It is shown in the original paper that in any network of conductors the resistance between any two points can be expressed by the quotient of two determinants, of which the denominator is formed directly from the numerator by taking the first minor of its leading elements. This may be symbolically expressed by writing

$$R = \frac{\Delta_n}{\Delta_{n-1}},$$

where n is the number indicating the *order* to which the first determinant belongs. As before, we will explain the method of procedure by means of an illustration.

Let there be a network in the form of a square, 1, 2, 3, 4 (Fig. 4); let it be crossed by a diagonal from 1 to 4; and let

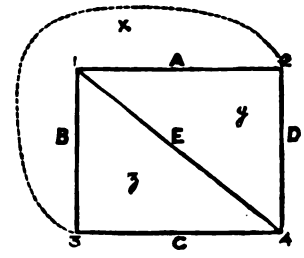

Fig. 4.

it be required to determine the resistance between the points 2 and 3. Let the resistances of the five conductors be A, B, C, D, E respectively. We proceed thus:—Join the points 2 and 3 by a line representing a conductor whose resistance is supposed equal to zero, and let this imaginary conductor have acting in it an imaginary electromotive force, e. We thus form a new mesh which we call *the added mesh*. Place symbols for the cyclic currents in each mesh, and write down the current equations for each cycle according to Maxwell's rule. In this case we shall obtain

$$e = x(A+B) - yA - zB$$
$$0 = -xA + y(A+D+E) - zE$$
$$0 = -xB - yE + z(B+C+E)$$

Then in the expression for R just given we have for Δ_n the determinant formed of the coefficients of the set of cycle equations taken in proper order, and Δ_{n-1} is the first minor of its leading elements. So that in this case we shall have

$$R = \frac{\begin{vmatrix} \overline{A+B} & -A & -B \\ -A & \overline{A+D+E} & -E \\ -B & -E & \overline{B+C+E} \end{vmatrix}}{\begin{vmatrix} \overline{A+D+E} & -E \\ -E & \overline{B+C+E} \end{vmatrix}}$$

It is easy in the present case to test the correctness of the result thus obtained. In Fig. 4, if we make A = D and B = C, it will be obvious that the resistance between the points 2 and 3 becomes equal to $\frac{1}{2}(A+B)$. And in the above expression for R, by making these substitutions for D and C and developing the determinants we shall obtain the same result.

After we have put in the conductor of zero resistance connecting the points between which the resistance is to be found we need not trouble to write the cycle equation, but may proceed at once to form the determinant according to the following rule:—Write down for the elements of the dexter diagonal the sum of the resistances which bound each mesh, *beginning with the added mesh* (proceeding afterwards in any order). Complete each row by writing in the resistance which separates the meshes whose resistance appears in the same row from the mesh whose resistance appears in the same column, prefixing the minus sign in each case, and writing zero for those elements which correspond to non-adjacent meshes.

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This rule will probably become intelligible on examining the formation of the determinant written above. It will be found that the determinant so found is always symmetrical, one half being, as it were, the reflection of the other half in the diagonal considered as a mirror.

As a second illustration we may take the somewhat interesting case of a circular wire A P B Q, with a diametrical wire, P Q, across it.*

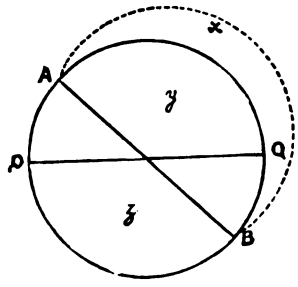

FIG. 5.

Take any two points A, B, at the extremities of a diameter not coinciding with P Q, but separated by an angular distance, θ, from it, and let us obtain the resistance of the circular wire so crossed between the points A and B. Join the points A, B by a dotted line of zero resistance. Call the three meshes so formed x, y, and z; let r be the radius of the circle, and let ρ be the resistance of the wire per unit of length. Then the

Resistance of branch P Q $= 2\rho r$,
" " A P $= \rho r\theta$,
" " A Q $= \rho r(\pi - \theta)$,
" " B Q is the same as that of A P,
" " P B " " " A Q.

Then the network determinant d_n is

$$\begin{vmatrix} \rho r\pi, & -\rho r(\pi-\theta), & -\rho r\theta \\ -\rho r(\pi-\theta), & \rho r(\pi+2), & -2\rho r \\ -\rho r\theta, & -2\rho r, & \rho r(\pi+2) \end{vmatrix}$$

which becomes

$$\pi\rho^3 r^3 \begin{vmatrix} 0 & \theta & \pi \\ -1 & 1 & 2 \\ -\theta & -2 & \pi \end{vmatrix},$$

and finally,

$$\therefore d_n = 2\pi\rho^3 r^3(\pi + \pi\theta - \theta^2).$$

The value of the minor of the leading element of the network, viz., d_{n-1}, is

$$\rho^2 r^2 \pi(\pi + 4).$$

Hence the resistance of the network between A and B = R is

$$\frac{d_n}{d_{n-1}} = R = 2\rho r\frac{\pi + \pi\theta - \theta^2}{\pi + 4}.$$

This result can easily be tested in the extreme cases.

It will thus be seen that Dr. Fleming's method is easily applied in all cases, whether the network is symmetrical or unsymmetrical, and is capable of furnishing an immediate solution in cases where other methods of calculating the resistance would be extremely laborious, if not altogether impossible of application.

* The treatment of this case is entirely due to Dr. Fleming, but he is not responsible for the illustrations previously given.

(To be continued.)

THE ELECTRIC LIGHT FOR THE POST OFFICE SAVINGS BANK.—We understand that the Maxim Weston Electric Company have just completed their contract with the Government for lighting the Post Office Savings Bank in Queen Victoria-street. The lamp to be used is the Weston wavy filament. Gas engines supplied by Messrs. Crossley Bros. will be used for the installation, this eminent firm having devised means whereby the disagreeable pulsation of the incandescent lamps has been overcome.

ON THE USE OF ALTERNATE CURRENTS FOR THE MEASUREMENT OF LIQUID RESISTANCES.*

BY MM. BOUTY AND FOUSSEREAU.

Two methods have been indicated by which the measurement of liquid resistances may be carried out with great exactitude. The one based upon the employment of the electrometer, and which we have adopted exclusively in our earlier investigations, is an admirable method, in that it eliminates thoroughly and absolutely the influence of the polarisation of the electrodes; the other consists of decreasing this polarisation until it is rendered a negligable quantity, by increasing as much as possible the active surface of the electrodes, and in having recourse to rapidly alternating currents. Desirous of obtaining an accurate comparison of the results given by the two methods and their relative precision, we have endeavoured to obtain the conditions indicated by M. Kohlrausch, so far as the resources at our command would permit. We procured two platinised platinum electrodes, each having $0^{mq}\cdot01$ surface, and made use of alternate currents furnished by a small Marcel-Deprez motor, revolving at a mean velocity of 100 revolutions per second.† These currents passed through a Wheatstone bridge in which a galvanometer was replaced by the Ader telephone.

From our preliminary experiments we found it necessary to obtain perfect insulation of the electro-motor and the resistances, but despite the care and attention we devoted to this purpose we failed, under the ordinary conditions of the test, to reduce the telephone to silence. Finally, however, we eliminated the inductive influences of the metallic resistances, and succeeded in obtaining absolute silence in the telephone. In order to effect this we dispensed with metallic resistances in the bridge, and employed a new liquid rheostat.

In the first experiment the four arms or branches of the bridge were formed of standard metallic resistances. We employed (1) a bridge by Elliott Brothers, of London, having three resistances of 10,000ω; and (2) four boxes of 1ω to 10,000ω, and two boxes of 10,000ω to 100,000ω, by Breguet. A series of careful determinations of the relative values of these resistances gave an invariable error somewhat below $\frac{1}{2000}$.

When the four resistances were small it was possible by regulation to arrive at a *minimum* of sound in the telephone, which, although far from being an extinction of sound, could almost be neglected. According, however, as the resistance was increased this minimum of sound became less and less perceptible, and at the same time the sound minimum became stronger as the resistance fell from a high value. The most important fact which should be stated is that *the bridge regulated for the minimum of sound was found to be absolutely incorrect in regard to the value of the resistances it contained*, and the error increased in magnitude with resistance. For instance, two arms of the bridge, A and B, were equal to 10,000ω, and the third branch, C, also to 10,000 ω. When regulation was made for the minimum of sound the fourth arm, D, was found to be 9,300ω instead of 10,000ω. The error, therefore, in the measurement of this resistance, supposing D to have been an unknown quantity, would have been 7 per cent. When C was made = 100,000ω, the value of D became 80,000ω, the error in this case amounting to no less than 20 per cent.

These results defy interpretation, unless it be admitted that the resistance boxes, such as are placed upon the market by the best makers, are not free from induction. The coefficient of self-induction of each coil is variable, and there cannot be any relation between the coefficient and the resistance proper. It can easily be seen, therefore, that the equilibrium of the bridge cannot be realised, when alternate currents are employed, by any combination of resistance coils contained in a box.

In replacing successively the first, second, and third arms

* Translated for *The Electrician* from the *Journal de Physique* for September, 1885.

† The motor, which was constructed by M. Carpentier, had a coil of about $0^m\cdot15$ in length and $0^m\cdot03$ in diameter, revolving between the arms of a magnet, formed of three plates of charcoal iron, each $0.^m\cdot01$ in thickness.

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of the bridge by liquid resistance free from polarisation much greater clearness is obtained, but not an actual *extinction* of sound. The effect of the induction in the coils continues to exist, and the measurements in consequence are illusory. The results are the more incorrect as the reversals are more rapidly made, and the most careful series of experiments, carried out with the same apparatus, give no guarantee of their exactitude. We have here a systematic and grave cause of error which does not appear to have sufficiently occupied the attention of scientific men who have made use of the method of alternating currents.

In the second experiment we constructed fixed liquid resistances, free from polarisation, by means of two vases of large capacity, such as, for instance, two battery jars, each containing amalgamated zinc plunged in a solution of a concentrated sulphate of same metal. The two vases were connected

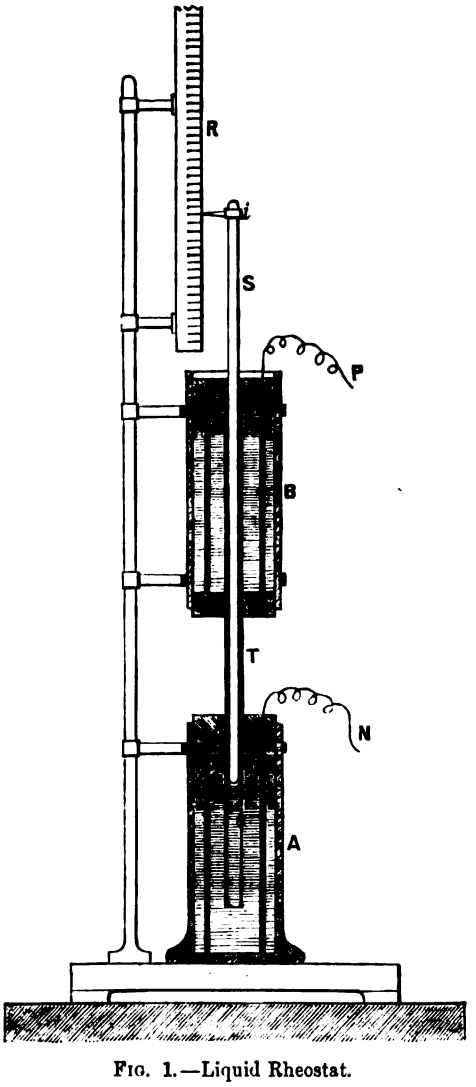

FIG. 1.—Liquid Rheostat.

by glass siphons, the number and diameter of which were arranged in accordance with the value it was wished to give to the resistance of the system. We then constructed a bridge of three resistances of this kind, and a liquid rheostat formed of a bitubular vessel full of sulphate of copper; a copper wire entered by one of the tubes, and constituted one of the electrodes, and a vertical capillary tube placed in the central main tube received the second electrode. This latter was also a copper wire, arranged so as to be raised or lowered at will, in order to vary that portion of the tube containing the liquid resistance. Under these conditions it was yet impossible to obtain absolute silence. The polarisation of the small copper electrodes played here the same part as the resistance boxes, and disturbed the equilibrium of the bridge. For the liquid rheostat, therefore, electrodes of large surface were found to be indispensable.

Liquid Rheostat.—Our rheostat (Fig. 1) is composed of two vessels, A and B, superposed upon each other, and each containing a cylindrical electrode of copper of a surface of several square decimetres. These vessels are connected by means of a vertical glass tube, T, open at both ends, in which is placed a plain glass rod, S, of almost equal section. The two vessels are then filled with a solution of sulphate of copper, and by raising or lowering the rod S in the tube the resistance can be varied at will. An index point, *i*, moving to the divisions of a scale, serves to indicate the position of the rod, and by an electrometric measurement of the increase of resistance represented by each division of the scale mentioned some useful data can be obtained. For absolute measurements it is, of course, necessary to make careful observation of the temperature of the liquid at the time of the test, for the reason that its resistance varies for each degree centigrade to the extent of $\frac{1}{30}$th of its value at zero. For relative measurements which require to be taken rapidly this correction may be dispensed with. One of our rheostats, of which we have made frequent usage, had a resistance ranging between 1,200ω and 5,000ω; it thus permitted of the comparison of two resistances in which ratio did not exceed 4 as a multiple. By varying the ratio of the arms of the bridge, however, with supplementary siphons, a range of from 24ω to 62,000ω was obtained for the smaller of the two resistances. We have not had occasion to exceed this limit.

The resistance which it was required to measure consisted of two glass vases, each containing an electrode of platinised platinum as before, connected by a narrow siphon, full of the same liquid as the vases. This resistance constituted the fourth arm of a Wheatstone bridge, in which the first two arms were liquid resistances, free from polarisation, and the third arm the liquid rheostat. We have operated upon chloride of potassium, chloride of magnesium, and sulphuric acid in various stages of dilution.

In every case we had the satisfaction of obtaining *absolute extinction of sound in the telephone.* With solutions which had but a small resistance, the extinction was got with great exactness, but with liquids of lesser density, the extinction, although apparently achieved, was yet shown upon an appreciable portion of the scale of the rheostat, and the relative error in the measurements became also appreciable in consequence. *This error is always greater than those observed in the electrometrical measurements made of the same liquids and under the same conditions.* As an instance of our meaning, we may cite the results given by a solution $\frac{1}{1000}$ of chloride of magnesium* compared with a solution of chloride of potassium of the same strength or concentration:

	Alternate currents.	Electrometer.
Mg Cl	1,609	1,546
K Cl	1,563	1,541
Mean	1,586	1,5435

Two tests repeated under conditions which, as far as possible, were identical, and with alternate currents, differed from each other to the extent of $\frac{1}{10}$th, whereas the difference between the tests taken with the electrometer seldom if ever exceeded $\frac{1}{300}$th. In regard to very weak liquids, the measurements made by the first methods are untrustworthy.

Concerning the exactitude of the alternate current method itself, the results of our experiments, conducted comparatively with the same liquids and at the same temperature, go to show that the mean of the measurements so taken bears about the same relation to the mean of the electrometrical tests that individual tests of the telephone may be expected to bear to themselves. The alternate current method yields good results when concentrated or moderately concentrated liquids are used in conjunction with large platinum electrodes such as those recommended by M. Kohlrausch, and, above all, when *non-rectilinear metallic resistances are carefully excluded from the four arms of the bridge.* Even with these precautions it is by no means certain that the best results will be obtained if it is attempted to apply the method to very weak solutions.

* $\frac{1}{1000}$ of Mg Cl + 6 HO.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE NEW YORK OVERHEAD WIRES.

It will be in the recollection of our readers that for some considerable time past the overhead wires of New York and its Brooklyn suburb have been under notice to quit, the Legislature having peremptorily enacted that either the said wires must get themselves buried within a given period or have their funeral undertaken by the local authorities without leave or ceremony. That period has now passed by; and, needless to say, the wires are still above ground as lively as ever, the owners not showing any disposition to incur the expense of interment, and the municipality being wholly unprepared with a suitable grave. The case is another illustration of the fact that it is one thing to pass a law and quite another thing to get it obeyed. It illustrates also one thing more which we on this side the Atlantic may do well to note, namely, that when we have tacitly winked at the growth of an abuse we cannot shirk all responsibility when the consequences have become intolerable. The critical stage has been reached in New York sooner than in London, because the process, or "progress" as some may call it, has been more rapid there than here. But we are travelling in the same direction, and the warnings we have repeatedly uttered on the unchecked multiplication of overhead wires in this metropolis are now fully justified by what has happened in New York.

In view of an evident determination on the part of the Telephone and Telegraph Companies not to remove the nuisance at the bidding of the Legislature, a Commission of Inquiry was instituted, apparently to devise means to enforce the law when the time of grace had expired. After devoting two months to the subject the Commissioners have issued a preliminary report. Their present conclusions are as sensible as one could expect under the circumstances, being, in fact, the recommendation of a system which in all essentials is identical with that of the British Post Office Telegraphs. It consists of underground conduits, either of timber or lead, along the main thoroughfares, with manholes and terminal posts at suitable intervals. The system, we need hardly say, is simple, more permanent, and in every way more easily maintained than any other; and where there are no subways already in existence, it is the least expensive. Though the first cost is not nearly so great as has been represented, and is repaid in time by cheaper maintenance, it is certainly greater than for overhead wires; and of course, when a large outlay has been already incurred for one system, the cost of superseding it becomes a very serious matter. This is the consideration which has paralysed all local effort hitherto, the evil having gone too far to be worth checking if it could not be wholly removed. On this point the Commission is silent; and we can only inferentially assume that its members desire to throw the expense upon the Companies.

For their part the Companies are evidently of a different mind. We are told that they mean to dispute the "constitutionality" of the law before they succumb, and if it be true, as is asserted, that they "had authority to string the wires through the streets," it does seem an arbitrary and unjust act not merely to rescind the authority, which the Legislature has a clear right to do, but to saddle the Companies with the cost of undoing their own work. In this country the Companies have neither sought nor obtained such authority; and although the absence of prohibition is a tacit consent which it would be very unfair to ignore altogether, still they have been fairly warned that they are running a great risk, greater it would appear than their friends in America. That the proprietors of overhead wires in New York are throwing every obstacle in the way of the enactment is natural, and is evident in every paragraph of the Commissioners' report. An American contemporary complains that there was not a single competent electrician upon the Commission. This is ungrateful. If there had been, the report would have been much shorter, more emphatic, and far less beclouded with nonsensical difficulties propounded in the interests of the Companies. The major portion of the document is taken up with discussing propositions made with no conceivable purpose except to demonstrate the impossibility of putting the wires underground. A vast system of subways is gravely discussed, only to be dismissed as ruinously expensive. "Solid conduits" are considered, and rejected on the less adequate grounds that if one wire fails the whole mass is worthless, and repair impossible, except at an expense "greater than the original" outlay. It was even discovered that gutta percha is no adequate protection to the conducting wires. Quite providentially a "curious disease" broke out in the gutta percha covering of the wires belonging to one of the Companies interested just while the Commission was sitting. Diseases equally curious and opportune are known to attack the human Britisher when he is summoned to serve on a jury, or to vote in Parliament when his Party wishes to be beaten. What is more to the point, we have known submarine cables, covered not merely with gutta percha but with solid iron of great thickness and strength, to be suddenly smitten—bitten through and through—with some fatal malady just when an opposition cable is being completed. These, however, are curious coincidences which a "competent electrician," had there been one on the Commission, might have at least partially explained to the Commissioners' satisfaction, if not exactly to the Companies'.

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It is gratifying to notice that the framers of this report, while loyally bent upon carrying out the edict of the Legislature, are warmly in favour of the telephone as a medium of social and commercial intercourse. They grow almost eloquent over the "last invented agencies of civilisation," which has established easy communication between Brooklyn and New York, "promoting its territorial extension," and increasing "residence in its beautiful outlying wards." If handsome dwellings are "no longer confined to the Heights," the circumstance is due, amongst other things, to the "growing telephone system," which not only benefits the subscribers, but "enhances the value of house property"—and, indeed, "of vacant lots where no houses stand." We do not presume to interpret this language; but it can hardly be other than friendly towards the telephone. Yet the conclusion arrived at is that the wires of this civilising agent must be put underground—perhaps, amongst other reasons, because the beauties of "outlying wards" and "vacant lots" are being wholly obliterated, and residence on "the Heights" becoming a terror and a burden. As to ways and means, the Commissioners are almost persuaded that the Companies, if left to choose, will adopt the best system themselves; and that, subject to the approval of the Local Board, they may be allowed to do the job in their own way so long as they do it effectually and without conflict with the municipal authorities who have charge of the pavements. As to time, nothing is specified; but we infer that the change is to be a gradual one, and that there will be no summary cutting down of wires such as was at first threatened. Probably, however, the Companies have not said their last about who is to pay the bill; on this point we have to wait later developments.

CORRESPONDENCE.

A PHENOMENON OF CURRENT INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I do not know that I can fully clear up the points mentioned by Mr. Williams, p. 433, because, though I have often observed the facts and formed some general idea of the cause, I have not gone into them seriously. The change of "according to," instead of "amounting to," in my letter, p. 413, is a correction of a printer's error, and it will be perceived that my interpretation comes to the same result as Mr. Williams's, p. 396, that "completing the secondary circuit relieved the primary coil." It causes a greater current to be generated in the secondary, and lessens that of the primary. The actual effect will be variable with every coil, as it depends on two elements of construction, the number of turns in the two coils and their arrangement, or in effect (1) on the E.M.F. which is developed in the several wires, and (2) the repetitions of the generated current and consequent reaction on the core.

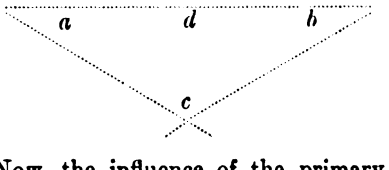
During the ordinary action of the coil, both circuits have an air space included at the moment of "break," but that of the primary is very small, while also its E.M.F. is much smaller than that of the secondary. But the division of the energy between the two coils, and the consequent currents generated, will vary with every alteration of the resistance of the secondary circuit. If this be metalically closed, the facilities of its path are so much increased that nearly the whole current will be produced there; but the energy will be mainly employed in producing E.M.F. rather than C, and will be largely expended as heat in the secondary wire. In these circumstances I should say that the resulting "ampere turns" reacting on the core may be less than when a considerable part of the energy results as "extra current" in the primary. If this were so, the rapidity of vibration of the break would increase, the force of its impact on the screw point would be lowered, and the spark at the break would disappear when the secondary circuit is closed. If I remember rightly this is what I have observed.—Yours, &c., JOHN T. SPRAGUE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My letter which you were good enough to publish on the subject of "Current Induction," p. 395, having called forth from your readers some comments by way of conversation, as well as through the medium of your columns, I hope you will allow me to draw attention to some misconceptions in connection with this subject which have come under my notice.

Persons come to me and urge that the outsetting primary current "does work" when it induces a current through the closed secondary circuit, implying that it does not do work when it sets out with the secondary circuit broken. I have little doubt that this class of thinkers (for I feel they number more than one) imagine that an induced current runs the whole rounder, so to speak, like a voltaic circuit. I will state what really happens.

Imagine a primary current from A to B arising, with a secondary circuit, *a b*, under its influence, whose horns are



united at *c*. Now, the influence of the primary current consists in causing a decline of potential in its own direction (viz., A to B). That is to say, a downward slope of potential is created along the line of wire *a d b*, or in other words an E.M.F. is set up between *a* and *b*, *for which there are two channels available*, viz., *a d b* or *a c b*. A current is remarked at *c*, passing in the "inverse" direction *a c b*; meanwhile, in the portion of the secondary circuit which is under the influence of the primary, the stream is going the other way, viz., *a d b*, instead of there being (as some appear to imagine) one continuous stream in the direction *b d a c b*.

Now, whether the secondary circuit be closed or open the work done by the primary consists in setting up the electrotonic state in the neighbouring conductor, or in other words, in creating the slope of potential already mentioned, and the consequent dispersion of electricity from *a* and accumulation of it at *b*. When the secondary circuit is not joined up at *c*, this distribution has to be made entirely through *a d b*, and the only difference is that the electro motion is made under greater resistance.

But there is an easy way of showing that the outsetting primary does its external work none the less with the secondary circuit broken. Set on the primary, and afterwards, while it is flowing, close the secondary; now cut off the primary, and the resulting "direct" induced current is the paying back of our invested energy.—Yours, &c.,

E. ALDRED WILLIAMS.

October 17th, 1885.

[The writer has since asked us to explain that the dogmatic form of the above letter is a mere *ruse*; he is quite aware that the "misconceptions" are the sanctioned view, and the opposed view a suggestion of his own.—ED. *E.*]

THE KAUFFER-GOLDNER BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The letter signed by Desmond G. FitzGerald, which appeared in your issue of 21st August, in regard to the Kauffer-Goldner battery, has escaped my notice until the present moment.

In reply I have to say as follows:—

The test of the Kauffer-Goldner battery was made under my supervision, and it is not my wish, any more than it is that of

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the inventors, to foist upon the public statements which are not true.

The figures quoted in your issue of 14th August, to which Mr. FitzGerald justly objects, must have been taken from some unauthorised source.

I will briefly state the conditions of the test, and the actual consumption of zinc.

Nine cells of the battery were used, which were hitched in series. In the circuit were placed two 8 candle-power incandescent lamps, which were hitched in multiple arc. A clockwork mechanism closed the circuit for five minutes and thirty-eight seconds, and opened it for six minutes. At the end of 310 hours, considerable talk had been made in the press that I purposely made the intervals of rest very close together because the battery required it. It is easier to answer unintelligent criticism by experiment than by argument, and so to silence certain critics who had become prolix in the information they gave the public on the subject of closed and open circuit batteries, I removed the clockwork and closed the battery on the lamp circuit for thirty consecutive hours; after which runs of eight hours were made at short intervals, followed by a final run of five hours, at which time the lamps began to burn low. The lamps had been lit to full incandescence for 202 hours during a period of 408 hours. The battery was not entirely exhausted, although no longer capable of lighting the lamps satisfactorily. Two and a half pounds of zinc had been consumed in each cell. The depolarising solution had not been renewed nor tampered with in any way.

The utmost precaution was taken to make it a fair test in every way.

The cells were placed upon the floor and covered with a large cotton cloth, fastened to the floor with sealing wax bearing the impress of my seal and those of the gentlemen for whom I was making the test. All the joints in the conductors were soldered and were also sealed with wax. These conductors went up through the floor of the room overhead, where the lamps were placed. This room was always open, and the lamps were watched by many people. The room where the battery was placed was locked and a wax seal was placed over the keyhole by the gentlemen for whom I was making the test.

There were no accurate photometric observations made, but the test was considered at an end when the lamps burned lower than competent judges believed they ought to burn in practical house lighting.

The above briefly states the conditions of the tests and the results obtained.

I might here add that since the test above described the battery has been rendered still more efficient by using the ingredients of the solutions in proportions corresponding more nearly to their chemical quantivalence, and by slightly altering the shape and dimensions of the electrodes.—Yours, &c.,

ALLAN V. GARRATT.

Boston, Massachusetts, U.S.A.

INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I see by a note in your journal that Prof. Hughes is investigating by means of the induction balance the superior transmissive power of copper to iron conductors, as pointed out by Mr. Preece.

Having employed copper aerial lines for many years past, I am of opinion that the cause of this difference is the lower electrostatic retardation of the copper, consequent upon its superior conductibility and smaller surface.

Some of our apparatus, which require the correct transmission of 6,000 currents per minute to control their movements, are perceptibly affected by the enlargement of the inductive surface of the wires by the moistening of their coverings during rain.—Yours, &c.,

F. HIGGINS.

The Exchange Telegraph Company,
21st October, 1885.

NON-MAGNETIC STEEL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As the subject of non-magnetic manganese steel has been attracting some attention lately, having been examined by Dr. J. Hopkinson and my brother, Mr. J. T. Bottomley, perhaps the following extract may be of interest to your readers. It is taken from a patent of Mr. F. A. Paget, No. 843, 1868:—

"A mixture of from 20 to 30 per cent. of manganese destroys the capability for getting polarised of cast iron, and a mixture with antimony has a similar effect on wrought iron."—Yours, &c.,

W. BOTTOMLEY, JUN.

Glasgow, Oct. 19, 1885.

BICHROMATE BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following description of a useful battery may be interesting to some of your readers:—

Six half-gallon stoneware jars, with holes for tap or plug. In each jar a round porous pot 9in. by 3in., surrounded by carbon plates and broken carbon. In the porous pot a zinc rod 8½in. long, weighing 1½lb. Solution of common salt and water. Solution for the six carbon cells:—

		s.	d.
Water	14lb.	—	
Potash bich.	1¾lb., at 6d. per lb. ...	0	10½
Sulphuric acid,	6lb., at 1½d. per lb. ...	0	9
		1	7½

I have four 2½ candle-power 4·8 volt lamps in places where the light is only wanted for a few minutes at a time. One is used as a night-light, to be turned on when wanted. Besides this the current is used through resistances for bells, gas, &c.; for this I use four cells in series. A third wire runs from the batteries to my room with six cells in series for a 10-volt lamp (5 candle-power) or other purposes. I am sure I understate the fact when I say the current is used only fifteen minutes a night, and for a second time this combination has lasted me over ten weeks. To equalise the wear of the solution, I empty all the cells together about the fifth week, and refill with the mixed solution. The loss of zinc is about 2lb., at 4d. per lb. equals 8d., added to cost of solution equals 2s. 3½d., or between ½d. and ⅓d. per night. A night-light alone costs ½d.

The carbon of the cells has just been overhauled after six months' continued use. There are not enough crystals of chrome alum to cover a sixpence; but in each cell is about 2oz. of a pale bottle green crystal, very brittle, and (unlike chrome alum) easily detached from the carbon.

I have never heard of the use of iron in these batteries in the place of zinc, and shall feel greatly obliged if any of your readers can give me any information on these subjects. I have tried a short experiment with the following result:—

7 cells, in each 1 iron plate, immersed surface 4in. × 1½
2 carbon „ „ 4in. × 2

and equally divided among the seven cells a solution of

Water, 6lbs.,
Potash bichromate, 12oz.,
Sulphuric acid, 41½oz.

This kept a 2½ candle-power 4·8 volt lamp at a useful light for 3½ consecutive hours.—Yours, &c.,

W. N.

THE ELECTRIC LIGHT AT MORECAMBE.—At a recent meeting of the Morecambe Board of Health, Messrs. Paterson and Cooper's tender for lighting the promenade by means of the electric light was received, and the question of its consideration was postponed. Messrs. Paterson and Cooper's tender amounts, we believe, to the sum of £1,700.

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THE OPENING OF THE FIRST TELPHER LINE.

Saturday the 17th October may prove historical in the annals of electrical science. The late Prof. Fleeming Jenkin, as is well known to our readers, designed a system whereby he hoped electricity might be utilised for the transmission of goods.

The development of this system received the name of "telpherage." Seeing that certain parts of Profs. Ayrton and Perry's patents relating to electrical railways contained the solution of the problem of sending, *without attendants or control*, a stream of electric trains, Prof. Jenkin invited these gentlemen to become his colleagues in working out the telpherage system. Experiments upon a practical scale showed that the thing would work, and the question now to be solved is, will it pay? The Sussex Portland Cement Company has been sufficiently interested in the system to adopt it for the carrying of 150 tons of clay used per week in their works over a distance of about a mile. The plans for this line were almost completed before the lamented death of Prof. Jenkin, and, with the necessary modifications always required, have been carried out under the supervision of Prof. J. Perry, who succeeded Prof. Jenkin as engineer to the Telpher Company.

Saturday the 17th October was the day set apart for the opening ceremony. A large party—some three hundred—of visitors was conveyed by special trains from Victoria to Glynde, where the line is erected upon the property of Lord Hampden. Among those present we noticed Sir F. Abel, Major Armstrong, Prof. Ayrton, the Hon. A. Brand, Major Cardew, Mr. Crampton, Mr. Latimer Clark, Mr. E. Cowper, Prof. Carey Foster, Mr. Graves, Prof. Hughes, Major Hutchinson, Admiral Sir E. Inglefield, Mr. Massey, Prof. Perry, Mr. W. H. Preece, Mr. C. E. Spagnoletti, Mr. Swan, Mr. H. Taylor, Major-General Webber, Mr. Willans, Mr. T. Wood, Mr. Woodhouse, and many others interested in applications of electricity.

On the arrival of the visitors at Glynde they were conducted to the engine house, and Lady Hampden upon lifting a valuable jewel, resting in its case, caused contact to be made, when the "skeps," already loaded with clay, started upon their journey to Glynde Station, which they reached in due course without a hitch, and the clay was turned into the railway trucks waiting to receive it, the skeps going back for another load. The whole of the arrangements were satisfactory, the "telpher train" went backwards and forwards, and although only one train was worked, it was sufficient to prove the practicability of the system. The question in the minds of those present, however, was not so much a scientific one as a commercial one. All knew the system would work, but they wanted to know if it would pay—what were its advantages as compared with a wire-rope system, or a light tramway. Those who support telpherage maintain that it can be used in places where neither wire-rope nor tramways are practicable. Its opponents deny this. Nothing but an attempt to utilise the system practically will prove the correctness or not of the views expressed.

The advantages claimed for telpherage are—first, that the trains will go round sharp curves without loss of power, whereas with the overhead wire rope haulage system there is a great waste of power, and considerable wear and tear of the mooring rope at every curve on the line; secondly, there are no wheels all along the line that require to be regularly oiled; thirdly, the employment of electricity enables water power to be utilised even when it is at some distance from the telpher line; and, lastly, the electric power can be tapped at any point on the line, and, without the trains being stopped or delayed on their journey, used to work stationary machinery, a turn up cutter at the face of one of the posts illustrating, on Saturday, this last advantage. As compared with any form of tramway or railway on the ground, the land need not be purchased, way-leave to erect the telpher posts being all that has to be obtained. That the system is applicable for many purposes is undoubted; whether it is superior to a wire rope system in these places is questionable. The solution of the problem commenced with the opening of the Glynde Telpher line; the complete solution will, however, be a work of time. If energy, confidence, and ability will command success, then the telpher system can hardly fail, for Mr. Pryor (the chairman of the company), Prof. Perry (the engineer of the company), and the staff are thoroughly convinced that telpherage will eventually prove almost as great a success as railways, not, however, as a substitute for railways, but as a cheap means of bringing the goods to the railway. The work to be now done is to convince the sceptical business man.

ELECTRIC CONDUCTIVITY OF METALS AND THEIR ALLOYS.

BY M. LAZARE WEILER.

(Concluded from page 437.)

Variation of Conductivity with Change of Temperature.—The influence of temperature on electric conductivity is well known. Heat expands bodies, and thus separates their molecules by spaces of greater or less width. It would seem to follow, therefore, that heat should modify the conducting power in a manner depending upon whether the molecule or the intervening space is the better conductor. In the case of metals, elevation of temperature diminishes the conductivity. Silver sulphide, on the other hand, according to Faraday, gains in conducting power as its temperature is raised. Non-metallic elements are unlike the elements in this respect. A familiar example is afforded by the incandescent lamps. The conductivity of the filament is notably greatest at the time of incandescence that when it is cold. Becquerel made researches upon this subject in 1846. Without considering the details of his method, we will limit ourselves to mentioning the fact and to giving some of his results. The coefficient of increase of resistance is given in the following table for each degree rise in temperature. The coefficient is the value of k in the formula $R = r(1 + kt)$, in which r is the resistance at 0° and R that at $t°$.

Mercury	0·001040	Copper	0·004097
Platinum	0·001861	Lead	0·004349
Gold	0·003397	Iron	0·004726
Zinc	0·003675	Tin, possibly containing lead	0·005042
Silver	0·004022	Tin, pure	0·006188
Cadmium	0·004040		

The change of volume due to the expansion has in reality no effect. The augmentation of conductivity, when this is the consequence, is nearly balanced by the diminution resulting from the increase in length, which is a part of this same expansion. The relative conductivity of several metals (the bodies of most interest in this relation) are given in the following table, which should be compared with that by the same physicist, previously given, for the mean temperature of 12·75° :—

	Conductivity. at 0°	at 100°.
Silver, pure, annealed	100	71·316
Copper, ,, ,,	91·517	64·919
Gold, ,, ,,	64·960	48·489
Cadmium	24·579	17·506
Zinc	24·063	17·596
Tin	14·014	8·657
Iron, annealed	12·350	8·387
Lead	8·277	5·761
Platinum, annealed	7·933	6·688
Mercury, distilled	1·7387	1·5749

We have at present no similar experiments of our own with which to compare these. We may therefore accept these results for the present, with the reservation before expressed, relating to the purity of the metals and the precision of the methods. We shall have occasion to refer to this subject in the next communication.

Electric Compared with Thermic Conductivity.—The prevalent notions regarding the identity of divers physical phenomena have led physicists to seek to determine the relation between heat, light, and electricity. Without repeating the theories bearing upon this subject, I may recall the opinions expressed in relation to the analogy between electric and thermic propagation, by giving the figures previously referred to, and specify the experiments, the results of which will form the subject of

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a later communication. The analogy referred to has been supposed to exist since it was known that some metals appeared in the same order when classified either by their electric or their thermic properties. Also metals are good conductors of heat and electricity, while dielectrics are generally poor conductors of heat. Furthermore, the coefficients of conduction for heat and electricity are for many metals nearly the same. The researches of Wiedemann and Franz yielded the following results :—

	Conductivity.	
	Thermic.	Electric.
Silver	100	100
Copper	74	73
Gold	53	59
Brass	24	22
Tin	15	23
Iron	12	13
Lead	9	11
Platinum	8	10
German silver	6	6
Bismuth	2	2

These results are certainly very interesting, and at first view tend to mislead those experimenters who seek to simplify the explanations of physical phenomena, and who are always seeking to unify the theoretical conceptions of elementary laws. Meanwhile, we do not find it possible to accept unreservedly these results, nor the conclusions which it is desired should be drawn from them. We know that the table of electric conductivities needs revision. Copper, for example, appears in the table of Wiedemann and Franz with a coefficient of 73 for electric conductivity, whereas it is well known to be entitled to rank with silver at the top of the scale. We find, also, some remarkable divergences in the following list :

	Conductivity.	
	Thermic.	Electric.
Copper	73·6	100
Gold	53·2	78
Zinc	19·1	29·9
Aluminium	19·6	54·2
Silicious bronze	68	98
Antimony	21 5	3·88
Tin with sodium	13·34	46·9

The whole question clearly deserves to be re-studied without the embarrassments of preconceived theories. We have undertaken this new study, and we will limit ourselves here to describing our preliminary experiments. These researches have been carried on with the valuable assistance of M. Jannetaz, Maitre de Conferences of the Sorbonne, who has willingly brought to our aid his profound knowledge of the subject, and the apparatus with which he prosecuted his previous labours in determining the conduction of heat in minerals. The process which he employed and which we have adopted is as follows :—The apparatus as devised by M. Jannetaz consists essentially of a plate upon which is placed the mineral whose conducting power is to be tested. This body has been previously prepared by coating a plane face of it with a thin layer of wax or grease. In contact with this is a small bead of platinum about the size of the head of a pin, which has been welded to the apex of a triangle of platinum wire. A current being sent through the wire heats it, the bead fusing the wax over a circular or elliptical space, whose dimensions, taking into account the temperature of the wire and the time of contact, afford data for determining the conducting power of the specimen. To complete the description it is only necessary to add that the wire is brought through a copper casing which is supplied with a current of cold water, and that the wire is also supported by a carrier, which facilities making contact with or withdrawal from the specimen. It is with this apparatus that we have begun our researches. Unfortunately, it has not been possible in the time available to prepare thin plates of the metals and alloys. We have been obliged to content ourselves with half-cylinder sections, cut from the little bars employed in the previously mentioned experiments. Under these circumstances, the external conditions may have modified the results, and we prefer at present not to exhibit numerical results which may require correction.

It is sufficient now to say that some of the results appear to invalidate the law of identity above referred to, and others lead to the interesting conclusion that there may be a difference of conductivity in the same metal depending upon the method of preparation, whether it was cast, drawn, or rolled. You will notice upon the specimens submitted to you, which bear traces of these experiments, that the elliptical form of the curved spaces takes a direction corresponding to the lamination of the specimen. We have completed the observations which we set out to present to you, and which, as you see, form a programme of researches to be made quite as much as of results accomplished. We wish especially before closing to call your attention to the double interest attaching to the subject which has enlisted your attention. From the practical point of view alone the subject is of the highest importance, as has been shown by the results obtained, bearing as they do upon the vast problem of transmission of electric energy. But we do not insist upon this point. The estimate of this subject from the scientific standpoint is no less great, involving as it does the nature of electricity itself.

Among the facts which we have noted, we will refer again to the strange anomaly exhibited by the alloys as conductors of electricity when we consider them as compound substances. This might serve as an occasion to review the theories promulgated by certain eminent physicists, Clerk-Maxwell among others. But these theories are yet such mere hypotheses, and their interpretation appears to me so abstract, that I fear to venture upon this ground. But there is no rashness in affirming that, in the resistance offered by a body to the electric current, the magnetic orientation of the molecules of each body plays an important part. Each of them, influenced by the passage of the current to a degree probably depending upon its constitution, modifies the resistance. The question may be asked whether the compound molecules of the alloys do not behave as other elementary electric couples, having a special electromotive force that determines the passage of the current, and which produces in the total mass a series of currents analogous to the so-called Foucault currents, the effect of which is contrary to that of the primary current. We are tempted to believe that in the alloys the chains of molecules of the same kind are not able to act like a cable made of wires of different metals. As the alloy of equal parts of gold and silver has already been referred to, let us determine the resistances under the different conditions. If the current be transmitted through two wires each a kilometre long and a millimetre in diameter, one being of gold and one of silver, the formula for derived currents enables us to determine the total resistance. The formula is :—

$$x = \frac{R_1 R_2}{R_1 + R_2}.$$

The resistance of the silver being 19 ohms, and of the gold 24·36 ohms, the total is by the above formula, 13·38 ohms. But a wire made of the alloy in these proportions, having the same length and a double cross-section, offers a resistance of 58·50 ohms. This result shows that the law governing derived currents does not apply in the case of conduction through alloys. Some other cause intervenes ; possibly such a one as is mentioned above ; perhaps an unknown cause which essentially modifies the flow of electricity.

We may be permitted to recommend this investigation to physicists, and we are ready to devote our efforts to the same end. If this task, to the accomplishment of which we wish to dedicate ourselves, is crowned with success, we shall be sufficiently recompensed by the satisfaction which labour affords to those who seek thereby to advance science.

ALUMINUM BY ELECTROLYSIS.—According to *La Lumière Elictrique*, Mr. L. Senet has invented a new process that permits of the manufacture of aluminum, as well as copper, silver, &c., by electrolysis. A current of from 6 to 7 volts and 4 amperes is made to act upon a saturated solution of sulphate of aluminum in the presence of a solution of chloride of sodium, the two solutions being separated by a porous vessel. A double chloride of aluminum and sodium is formed, which is decomposed, and the aluminum that is set free deposits upon the negative electrode.

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IRON SHIPS AND COMPASSES.

The Philadelphia *Times* gives an account of adjusting the compasses of iron ships :—

The business is monopolised by three persons in the United States—two in New York and one in Philadelphia. An iron ship, said one of these professionals, is a great magnet. The magnetism of such a ship is technically known as "permanent" from having received the same from some other magnet itself styled permanent. The position the vessel occupies in the shipyard while in course of building is the principal feature in the shaping of her magnetic influence. A vessel lying due north and south on the stocks will be highly charged with magnetism. Every blow struck upon the iron plates of the sides, upon the rivets, or even by the caulker, has a pronounced effect upon the ship's magnetism. In shipbuilding it is impossible to reverse the manner of striking the metal, and the result is that the magnetic currents are not equalised. If a vessel that was built north and south in the yard travels generally north and south she loses a great portion of her magnetism, and a corresponding change is noticeable in her compass. The lines of magnetism always run in a contrary direction to the position the ship occupied in building. Occasionally it happens that a variation of but one point will be noticed when the ship is headed north-east, but when headed south-east five or six points of variation exist. The magnets used to neutralise the ship's magnetism consist of large bars of iron, spheres, spheroids, coils and, in fact, iron of almost every shape. These are placed in different portions of the vessel and exert a great permanent influence the further away they are placed. If the engines are changed during the trip, if new boilers are shipped, iron taken aboard or "patches" put on the sides, the magnetism of the ship is proportionally disturbed, and a readjustment is necessary.

THE BEST FORM OF DYNAMO.

In a recent interesting paper on "The Best Form of Dynamo," read before the National Electric Light Association of America, Mr. A. E. Sperry, of Chicago, the author, said :—

"The best dynamo is that which with economy operates continuously with the least expense ; one that does not require the constant attention of an expert (by no means, however, underrating efficiency in an attendant); one which has no delicate parts liable to derangement, one in which all the parts are accessible for cleaning and proper attention. Large journals, heavy framework, and substantial construction throughout are not to be overlooked in dynamo machinery any more than in a locomotive. A tendency, which I am pleased to see is becoming less prevalent, has been toward developing the greatest possible current with a given size or weight of machine. The construction in this case is generally too delicate, and all parts are overworked to such a degree that they are constantly giving way. The effect of this upon the commercial operator and public generally has been disastrous, establishing the impression that all electrical appliances are inherently unreliable. The latter constructions are more durable, less delicate as to details, and generally more satisfactory; although it is true they may occupy a slightly increased floor space." After dealing at length with the subject, Mr. Sperry concludes :—"The matters going to determine the best form of dynamo are so numerous, and the various forms of dynamos being best adapted each for its peculiar sphere, that a general formula, prescribing that form which is best in all cases would be impossible. The art, however, has brought dynamo machinery, the construction of which at first was attended by so many difficulties of a high scientific nature, down to a sufficiently practical basis, so that good judgment with regard to ordinary mechanisms of a higher order are relevant to the more salient features, and may be depended on largely in guiding those interested in investigating this class of apparatus."

THE DISTRIBUTION OF ELECTRICITY.*

BY PROF. GEORGE FORBES.

(Continued from page 442.)

LECTURE II.

In my last lecture, I introduced to your attention the elementary principles which must guide the engineer in the selection of the right size of mains to use. These principles maintain whether it be a private installation of the electric light or a large supply from a central station. But, in the future, I shall confine my remarks chiefly to the latter class. In whatever manner the mains be laid down, the mass of copper contained in them is very large, and their establishment constitutes a large portion of the prime cost of laying down a system of central station lighting. For 100,000 Edison lamps we require over a ton of copper per yard run, and everyone knows how rapidly the number of miles of mains mounts up, even in a small district, owing to the large number of side streets.

Now, when a bridge like the Forth or the Tay Bridge, or the Brooklyn Bridge at New York, is designed, the engineer spares neither time, labour, nor expense in his preliminary calculations of the weight of metal required in the several parts to combine strength with economy. In such bridges the mass of metal is enormous, and the reduction of cost in this item is very important, independently of the fact that, within a certain limit, the less metal there is in it the more efficient is the bridge. Consequently, the proportions of the different parts must be most carefully calculated by the ablest mathematicians.

Now I maintain that exactly the same care should be taken in the estimation of the proportions of different parts of our electric mains. It is a point which has been sadly overlooked in the past, even by some of the most advanced and far-seeing of electricians. But when we consider the enormous amount of capital which must be sunk in mains I hope that engineers will see how intensely important it is to spare neither trouble nor expense in preliminary calculation in order to ensure the best result.

Now, in the present state of electric lighting economy is of primary importance. Judging by the experience of the New York central station for electric lighting, we should be prepared to deny the possibility of economically furnishing the electric light to the British public. I, however, do not hold this view. I see several defects in that example of electrical distribution. The dynamos are of an expensive kind, and the outlay in this matter has been excessive. Moreover, the mains are laid on unsound principles, and are both expensive and, I believe, unsatisfactory. The general scheme for an installation is not to be written down casually on a few sheets of paper ; it requires weeks, or even months, to prepare the estimates, and to calculate the requirement of any such central station. I have no doubt the effects that I have alluded to are due largely to the early period at which that station was designed. But even in later estimates, and in our own country, I have seen the want of that detailed calculation which can alone lead to economy.

In any system, at the present time, economy is the main thing to be considered in designing a system of distribution. Other difficulties, such as equalisation of potential, must be looked upon as difficulties to be faced and conquered by the engineer.

In my previous lecture I have given you three reasons why we must not try to economise too much by laying very thin conductors.

1st. It is not economy, on account of the wasted energy in heating the conductors.

2nd. The conductors may become so hot as to injure insulation, increase the resistance excessively, and even be uncomfortable to the foot passenger.

3rd. The fall of potential over a district, and the variation of the potential at each point of a district, are both increased by thinning the wires.

I showed that, by due selection of the method of laying mains, the second can be reconciled with the first, which thus becomes paramount, leaving the third to be overcome by the engineer as best he can.

I showed you the general principles which must guide us in the economical selection of the size of mains, and I gave you some tables which, I trust, will be found of great value to the engineer. Nothing is there chosen for him. He may put his own price on the cost of an electrical horse-power and on the cost of laying mains. In any special case, and in all parts of the scheme he is designing, these tables give him, almost at a glance, the economical size of main he must employ. He can then, by the aid of my formulæ, determine approximately the rise of temperature under different systems of laying, and he will see whether these mains may be laid in a single conductor of circular section, a flat sheet of definite thickness, or a series of cables side by side.

Then comes the question of equalisation of potentials, which we shall have to deal with very fully in this and the following lecture.

I shall now, by way of introduction to what follows, lay before you the principal diverse systems which have been proposed, and shall afterwards examine each in detail. These are five in number, varying either in the way the lamps are connected with the main, or in the introduction of some special appliance. They are as follow :—

1. Multiple arc.
2. Series.
3. Multiple series.
4. Accumulators.
5. Secondary generators.

* The Cantor Lecture of Professor George Forbes, delivered on February 9th, 1885. From the *Journal of the Society of Arts.*

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Some of these have a large number of sub-heads. I shall confine myself to-day to the first class, as being at present the most important. It will be convenient to subdivide this system into several classes, which I venture to name as follows:—1. Parallel line. 2. Reserved parallel line. 3. Network mains. 4. Tree mains. 5. Multiple tree mains. 6. Independent wire mains.

Lamps in Series.—The oldest propositions for electric lighting had no reference to multiple arc. It was proposed to put all the lamps in series. This method economises largely in the cost of mains, but the number of lamps which can be supplied is very limited. The pressure required for lamps in series is greater than for lamps in quantity or multiple arc, in proportion to their number. The hydraulic analogy to electricity is always instructive. Now a lamp is represented by a water-engine or turbine giving off a certain amount of energy; a certain difference of pressure between the inlet and outlet of the water-engines is required to give off this energy. If, now, the outflow goes into a second water main, which again feeds a second water-engine, these engines are in series, and the pressure which must be supplied is exactly proportional to the number of engines placed in series. If the water-engines were all put upon the same main, the pressure required would be the same as for one, but the volume of water required would be greater than for one, exactly in proportion to the number of water-engines. Moreover, the size of pipe must be increased to allow this larger volume to pass without too much resistance from friction of the pipes.

These hydraulic facts, so simple and self-evident, are the exact analogues to facts in electric lighting. If lamps are in series, the electric pressure must be increased in proportion to their number. The electric mains supplying many lamps in multiple arc require the same pressure as for one lamp, but the size of the mains must be increased to prevent waste of energy by their resistance to the electric current.

Thus, if we have ten lamps in series, the current is one-tenth of what is required for ten lamps in multiple arc, and hence, on the economical considerations, the copper mains may be about one-tenth of the sectional area.

But the number of lamps which can so be put in series is limited. The highest potential which has been used hitherto, so far as I am aware, is 5,000 volts, and some people will say that even this is dangerous. I do not hold this view at all. If, as in America, a line be properly insulated, and if it be tested once or twice a day at the dynamo house, there is no real danger to consumers; and if, as in America, the workmen at the dynamos wear india-rubber gloves or the homely golosh, there is no danger for them.

I have no hesitation in asserting that the dangers from high potential electricity are far less than those from gas. Hardly a week passes but we read of dreadful explosions of gas. Suffocation is not uncommon, and in the first days of gas, when ignorant people often blew out their light, it was a dreadfully common occurrence.

If, now, we have 5,000 volts, and consume 100 volts in each lamp, we can only put 50 lamps in series. But, on the other hand, if such a system were to be adopted, it would be desirable to use lamps of much lower potential. When talking of the multiple arc system, I said it was desirable to use lamps of as high a potential as possible to economise the mains; so here I say, in a series system, we must use lamps of as low a potential as possible, so as to economise pressure. If we could have 20-candle lamps of 2 volts, we could work 2,500 lamps off a single wire with 5,000 volts (neglecting the resistance of leads). Assuming 3 watts per candle-power, this would mean a current of 30 amperes. In many cases this would be a highly economical system of distribution. There are, however, two objections to this plan which I look upon as fatal.

If one lamp is put out of circuit, it puts out all the other lamps. Consequently, the switch for a lamp must be one which will short circuit it, just as the plugs of a resistance box cut out resistances by short circuiting them. Then, the engine-driver must regulate his dynamos so that the current is constant. Automatic adjustments have been made for this purpose with arc lamps, and their action is excellent. These are to be found in all American arc systems, and are a great point in their favour.

If, however, the filament of a lamp breaks, all the other lamps in the series go out also. It would be necessary to have an automatic arrangement to short-circuit a lamp when its filament broke. This is no easy matter, and could hardly be done without a local battery, or a second wire from the dynamo. In any case, the introduction of any such apparatus into each lamp would add to the cost and liability to get out of order.

It may be said, however, that with the thick flow-resistance lamps of 2 volts ($\frac{1}{5}$ ohm), they would not break, but would be changed long before they got thin enough to break. In this case, however, the second objection is fatal.

The second objection is that with such thick filaments for lamps it would be impossible to get anything like a candle for three watts. I I think it was in 1874, when the Russian Logodine showed his incandescent lamps of thick carbon, that I tried some experiments at Anderson's College, Glasgow, where I was then Professor of Natural Philosophy. These experiments convinced me that incandescent lamps of that kind could never be economical. The heat carried away by the terminals was so great as to waste a large part of the energy put into the lamp. This is the objection which I have to the Bernstein lamp. I shall never forget the astonishment with which I first saw one of Mr. Swan's lamps with a thin filament. My astonishment was at seeing the filament glowing white up to the terminal. This can only be done to perfection by a lamp of very high resistance.

I remember seeing an able man of science showing some of the small fairy lamps to a scientific audience, and he asserted that its efficiency was doubtless the same as the 20-candle lamps. "because it is made of the same material." This was a serious misstatement.

I think enough has been said to convince you that, although in some cases this system may be worthy of consideration, it is not generally applicable. If the lamps are of low resistance they are not economical. If of high resistance we have few in series, and require a special device to short circuit a lamp when the filament breaks.

It would not be well, however, to leave this system without pointing out to inventors that it has one more advantage as compared with the multiple arc system.

Our present lamps (designed for multiple arc) have a serious drawback compared with gas. You cannot lower them to give less light. Even if there were a means of reducing the current through them you would not get economy because of the lowered temperature. Now with the series arrangement it is conceivable that the filament might by some means be lengthened and shortened, and since the current is constant, the brightness would depend on the length, and all lengths would be equally economical except for the absorption of heat at the terminals. I do not wish to invent, so I will say no more.

In America, arc lights are seen in series, sometimes to the number of 100. One cannot help feeling pleasure either in seeing the dozens of dynamos at work in the central station, or in admiring the graceful curves of overhead wires, well insulated, and supported on well-shaped steel poles, as in Philadelphia, and in seeing the bright light which they are spreading over seventy miles of street, and with which they are gladdening the hearts of thousands In some systems, with ten amperes flowing, an arc lamp is replaced by ten incandescent lamps in parallel, each using an ampere, and with switches to substitute resistances for lamps.

Mains with Lamps in Multiple Arc.—I think it may be fairly assumed that a 16 or 20 candle-power lamp is what is most likely to be generally adopted. It is found that we can get one candle-power for an expenditure of three watts of work. Now this three watts is the product of the current and the pressure, and may be made up in a variety of ways. We may increase the amperes of current and diminish the volts of pressure, or *vice versâ*. So far, however, as economy of mains is concerned, there is no doubt what is the best course to follow. The smaller the current the smaller are the mains. Hence it is clearly desirable to use lamps of a high potential—100 volts is at present about the limit that is used—but I am informed by Mr. Swan that equally good lamps could be made of 400 volts if there were a demand for them. There is at present an absurd regulation of the Board of Trade limiting the pressure in houses to 200 volts; but I think we may take it for granted that more enlightened views will ultimately prevail. If such lamps were used the cost of mains would be reduced to about one quarter, which is, of course, a very great step.

Here, then, is a step which, according to the information before us, can be taken at once. Why it is not taken I am at a loss to understand. If lamps of 20 candle-power can be made with a long life, using 400 volts and ·15 ampere, the question of central station lighting on economical principles is advanced enormously. The inventors and manufacturers are alone to blame if, by delaying to take this step, they hinder the adoption of this system of lighting.

These remarks apply, more or less, to nearly all the systems of distribution, but especially to the multiple arc system, where the mass of copper in the mains is so great.

Now let us look at the simplest distribution, where we lead mains along a single street, and take off the current at various points, using each such point as a source of supply to a house, or it may be to a whole district.

The diagrams below show different systems of laying the mains. In the single parallel line it will be noticed that the potential falls off as we go farther from the station. If the size of conductor is proportioned to the current with 1½ square inch per 1,000 amperes of maximum current, the fall of potential is regular, and amounts to 3·22 volts per 100 yards of double conductor when the maximum number of lamps are in use.

This is a good opportunity to draw attention to a point which meets us in studying nearly every system of distribution. Since the size of conductors is proportioned to the current, they are abruptly diminished in section at each point of consumption. It follows that, so far as weight of copper is concerned, this system is equivalent to one in which separate wires all of the same size go from the central station to each point of consumption.

The difference between these two plans—(1) the massive main system and (2) the independent wire system—consists in this, that while their action is identical in reducing the pressure when all the lamps are lighted, their action is different when some lamps are extinguished. With the independent wire system, the conductors leading to points of consumption not in use lie idle. In the massive main system the equivalent mass of metal is used, under the same conditions, to diminish the resistance of conductors to the points of consumption which are in use. This would seem at first sight to be all in favour of the massive main system; this, however, is by no means sure. If only the nearest and most distant points of consumption were in use, and R be the resistance of mains between these points, V the pressure at the near point, and r the resistance of lamps at the far end, the energy used up by the distant lamps and the mains to them is $\frac{V^2}{R+r}$. The current is $\frac{V}{R+r}$. R is greater for the independent wire system than for the massive system. Hence the current and energy used are less with the former than the latter system. Moreover, since the current is less, r is greater. Hence, *à fortiori*, the energy used with an independent wire system is less. In fact, with the massive mains, the distant lamps will be far too bright. If, however, the fall of potential with the maximum current is only a few volts, this would not be important.

The system of independent wires takes away from the inconvenience of varying pressure at definite points of consumption. It seems at first sight to be ridiculous to think of having a separate wire to each

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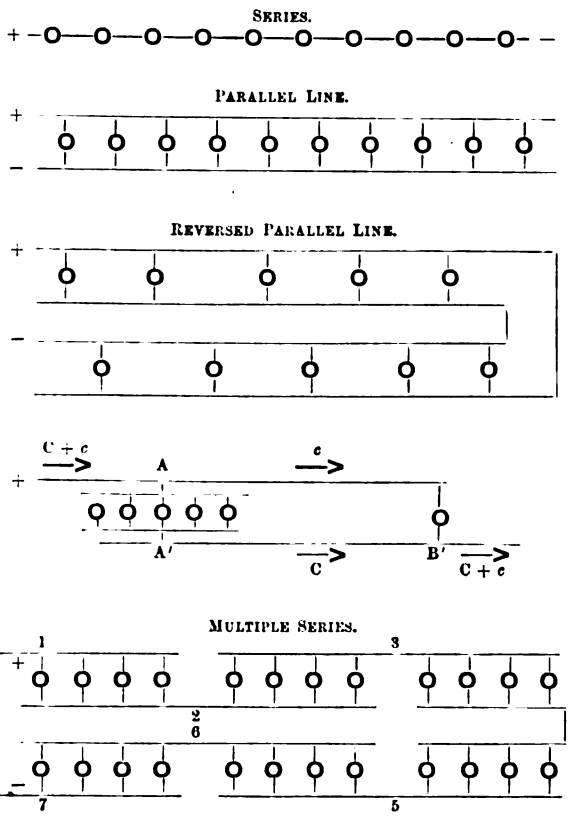
lamp from the central station. But it is by no manner of means ridiculous. In fact, it is well worthy of serious consideration.



In a previous part of the lecture I have shown what loss of energy we must allow in the leads and other conductors. Now this loss of energy shows itself by a fall of potential. If δV be the difference of potential between two points of a main, R the resistance between these points, and C the current, then $\delta V = C R$.

Now, I have resolved to assume in these lectures a section of 1½ square inch per 1,000 amperes. The resistance of 100 yards of a copper conductor of this section is ·00161 ohm, and $\delta V = 1{,}000 \times {\cdot}00161 = 1{\cdot}61$ volt. That is, we have, with such a conductor, a fall of 1·61 volt in every 100 yards of a single conductor, and a fall of 3·22 volt per 100 yards of double conductor. This takes place when the maximum current is being used. With a smaller current the loss is less. With 500 amperes to the 1½in. conductor, it is only 1·61 volt, and with 100 amperes or less it is nearly inappreciable. Now, while it is very satisfactory to the engineer to find that with small currents there is so little waste of energy, still there is a counterbalancing disadvantage of serious importance, I may say the most serious importance, in considering the question of laying mains. [In the following remarks I will assume that the engine is perfectly governed.] Suppose there is a distance of 500 yards between the engine house and the farthest lamps, and that lamps are being supplied all the way along, and that the conductor is properly proportioned to the current, on economical considerations, at every point. Then while the maximum number of lamps are in use those nearest to the engine house have an electrical pressure 16·1 volts higher than those farthest from the engine. Well, this might be counteracted by causing the consumers at a distance to use lamps of 16·1 volts higher than those farthest from the engine. Well, this might be counteracted by causing the consumers at a distance to use lamps of 16·1 volts lower potential. That is all very well while the maximum current is flowing. But when the number of lamps is reduced one-tenth, the difference of pressure to the two consumers is only 1·64 volt. Thus, if the nearest consumer has a constant pressure the distant one has his pressure varying by 14·49 volts. It is true that in this case we might vary the pressure at the engine house, so that the near consumer was 7·25 volts below, and the distant one 7·25 volts above his normal pressure; but even these variations are very serious. A variation of 7·25 volts in the potential of lamps is a most serious matter, even if we look at this variation as being only 3·62 volts above and below the pressure for which the lamp is constructed. To illustrate this I will give you three curves on a diagram. The first shows how the candle-power is affected by the pressure, the second how the life is affected by the candle-power, and the third how the life is affected by the pressure. The first is Mr. Edison's table of 1883; the second is from the experiments of Mr. J. Zacharias; and the third I have deduced from the tests of Woodhouse and Rawson lamps at the Vienna Exhibition. Generally, in 100 volt 16-candle lamps, a volt makes a difference of a candle.

I will now show you, experimentally, the fall of potential along a main. I have three lamps of equal brightness; when I connect the two at opposite ends of my main, the distant one is much feebler than the near one. If I insert a third half way, the distant one falls still more, because the main has to take more current. [Experiment.] This is one of the most serious problems which have to be considered in engineering the mains of a central station, and a large portion of this course of lectures will be devoted to the devices which have been proposed for getting over the difficulty. I have next to describe to you the different systems of connecting the lamps of consumers with the engine house. In the remarks which have gone before, I have confined my illustrations mainly to a multiple arc system; but there are several others, each of which has certain advantages. With the massive main system it has sometimes been proposed to equalise the pressure for lamps over a district by putting in proportionate resistances at the points of consumption. It has also been proposed to prevent variation of pressure when the consumption varies, by making these resistances adjustable automatically. This, however, must not for a moment be thought of. I pass over the fact that automatic adjustable resistances have generally been a failure, because the designers are alone to blame for this; but I do insist that an economical system of working is incompatible with the free use of resistances in the working circuit, which use up a large quantity of energy. It is better to use lamps of different qualities in different parts of a district than to introduce such resistances, and the engineer must find some other means of dealing with the variations of pressure with varying consumption.

The remarks I have made about the independent wire system must be looked upon as parenthetical. We shall recur to the subject. We have now examined the single parallel line, and have seen that, so far as weight of copper is concerned, it is equivalent to a separate wire to each lamp. We have also seen how the pressure falls off as we go from the station.

The reversed parallel line (Fig. p. 1,042) was devised to prevent this fall of pressure. Two wires run side by side; one end of one wire is attached to the + pole, and the other end of the other wire is attached to the − pole. Thus the current supplying each lamp goes around the whole circuit, and so there is a tendency to equalise the pressure for all lamps. In the diagram the wires are shown of taper form, but they have been generally taken to be of uniform thickness. It has been shown by Prof. Ayrton that, in this case, the pressures are not equalised if a larger current is taken off at one point than another. Suppose at point A a large number of lamps is supplied, and at B a small number, so that a current C passes through the lamps at A, and a current c through those at B. Let R be the resistance of A B or A′ B′. The fall of potenlial from A to B is c R, and from A′ to B′ it is C R. Hence the pressure at B is greater than at A by the quantity $(C - c)$ R; *e.g.*, with 500 lamps at A and 10 lamps B, and 0·75 ampere per lamp, and with A B = 200 yards, and resistance = ·0032, the fall of pressure is 1·17 volt.

Mr Kapp (*Electrician*, May, 1883) has gone further, and shown that with lamps equally distributed over the whole line, the middle ones have less pressure than those at the two ends. But it must be noticed that if at each point the section of conductors is made proportional to the current, then the quantity $C R' = cR$, and the fall of potential to both terminals of a lamp is the same, where R R′ are the resistances of A B and A′ B′ respectively. If the size of conductors be properly proportioned, the pressure is constant at all points of the line. Now what does it mean to make the section of conductor proportional to the current? It means that, so far as weight of copper is concerned, it is equivalent to having a separate wire for each lamp going round the whole circuit. Here is the weak point of the whole system. Equalisation of pressure is attained by putting in useless resistance. The wire might go up to the lamp, and then back to the dynamo, without making the whole circuit, and equalisation of pressure attained by putting in a resistance at the lamp equivalent to the copper wire which has been cut out. Such a resistance could be made of much cheaper material than copper. Thus the reversed parallel system, beautiful at the first glance, is the same in efficiency as, and inferior in economy to, the direct parallel system, with resistances in the lamps to equalise pressure.

It seems to me that this consideration is absolutely condemnatory of the reversed parallel system for application to mains. It is worse than the direct parallel system with resistances introduced, and we have already condemned the latter. It becomes, then, hardly necessary to speak of it further, but a somewhat similar arrangement may be used with multiple series systems. I cannot refrain from pointing out to you a device by means of which the equalisation of pressures might be maintained, even when the maximum number of lamps is not in action. In this case the proportion of the + and − conductors should be altered in some parts. Suppose the conductors to be made up of a number of insulated wires in sections, and that at each end of a section each wire is attached to the + bundle, or the − bundle of wires. It would be easy to design an arrangement by which these terminals could be changed from the + to the − bundle, or *vice versâ*. It would be also easy to design an automatic switch by which, when the size of the + and − mains was not proportioned to the currents in them, the two terminals of one or more wires should be so transferred from the bundle which is too great to the one which is too small.

We have now reached the most important and difficult part of the problem. Leaving behind the case of a single street, we come to a district. In the choice of districts to light, care should be taken in the selection of those which will give the best return for outlay of money and cost of maintenance. It is needless to say that a district with many theatres and restaurants is favourable, and that many storied houses have a larger consumption for a given area than a district of low houses. The first thing to be done is to estimate as well as possible (and it is not possible to be exact) the number of lights to be supplied in each part of the district. The only alternative to this method would be to lay mains large enough to supplant gas entirely. This would involve a great outlay in mains which for years would generally be lying useless, or at most diminishing in a feeble degree the cost of wasted energy. It is quite right that the engineer should calculate the cost of mains on these lines, but in general it could not be recommended to spend so much money on laying

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them. It is generally better to trust to laying additional mains as required.

Tree Main.—First, let us suppose that we have all the mains connected in parallel with all the dynamos. This is a case which I find has been well discussed by Mr. Kapp in *The Electrician*, August 4. 1883, but it is a system which we shall soon find reason to condemn. The reason why I object to this system is that the size of mains is not made dependent on considerations of economy, but on that of variations of pressure allowed by the Board of Trade. This must be the case with the above mode of working, if the district is large. The difference of potential between the near and distant lamps is insensible when there are few lamps burning. The difference when the maximum number of lamps are burning is considerable. Hence, if the near lamps are kept at constant pressure, the far lamps will vary at different times by the amount of the difference between the near and far lamps, when all are on. Now, the Board of Trade forbid a greater variation than 10 per cent. (5 per cent. up and down). Hence the maximum difference of pressure between near and far lamps must not exceed 10 per cent. Here I may say that 10 per cent. is a far greater variation than is permissible. Two or three per cent. up and down is quite as much as can be allowed. Now, Mr. Kapp assumes the size of conductors to be limited by these considerations. He assumes the maximum difference of pressure between the nearest and the farthest lamp to be the maximum which can be allowed. On this view notice the following facts:—

1. If we have two similar areas, with equal number of lamps to light, one larger than the other, the mains in the former must be so increased as to make the fall of pressure to the most distant lamps the same in both. Hence the section of mains is proportional to R, the maximum distance, other things being equal, and their length varies as R, so the cost varies as R^2. 2. The section of mains varies as n, the number of lamps. 3. The section of mains depends in two ways on the pressure required for a lamp; (α) the current and section of mains are less in proportion to the pressure; (β) the variation in pressure allowable (being a percentage) is proportional to the pressure. Hence, on the whole, the section is inversed, as the square of E, the electric pressure of a lamp. 4. The section of mains varies inversely as p, the percentage variation of pressure allowed. On the whole, the section of mains and the cost of mains (assumed proportional) vary as follows:—

$$\text{Section varies as } \frac{n\,R}{p\,E^2}$$

$$\text{Cost varies as } \frac{n\,R^2}{p\,E^2}$$

Mr. Kapp has deduced a coefficient from actual estimates and finds:—

$$\text{Cost in pounds} = 0{\cdot}9 \times \frac{n\,R^2}{p\,E^2} \text{ or } 1{\cdot}2\,\frac{n\,R^2}{p\,E^2}$$

where R is given in 100 yards, and E in 100 volts, according as the most favourable or the least favourable of likely distributions is adopted. [The coefficient 1·2 is used for equal distribution of lamps, and 0·9 when the number of lamps at distance r varies as $\frac{1}{r}$.] To take an example where $n = 60{,}000$ lamps $R = 7$ (hundred yards), $E = \frac{1{\cdot}00}{1{\cdot}40}$ (hundred volts), $p = \frac{4}{10}$ ($\frac{2}{5}$ per cent. up and down). ∴ Cost is between $\frac{£661{,}500}{£135{,}000}$ and $\frac{£882{,}000.}{£180{,}000.}$ If we used lamps of 420 volts, the cost would lie between £15,000 and £20,000, instead of the lower pair of figures. But these figures are of no value; first, because 10 per cent. is too great a variation of pressure; and, secondly, because the economical size of mains is the primary consideration, and we must find a way out of the difficulty of variations of pressure.

We must now consider to what distance we may use the method of connecting all the mains, and charging them all with the same dynamos. I think we may say that 2 per cent. variation of pressure up and down is permissible. This gives a variation of four candles in an Edison 16-candle lamp. Now, by attention to the dynamos, this allows a range of 4 per cent., all lamps in the district requiring the same pressure. If telegraph wires came from the most distant and nearest lamps to the engine house to indicate on voltmeters the pressure at those points, the engineer would have his instructions to keep the near lamps as much above the normal pressure as the distant ones are below. Suppose that 100 volts is the normal pressure. When very few lamps are on, both near and distant mains would indicate 100 volts. This is the case where metal is laid for a large number of lamps, even at the distant points, and in any actual installation it may be taken to be approximately accurate. When the maximum number of lamps are on, there will be 4 per cent. difference. The engineer keeps the near lamps at 102 volts, and the distant ones at 98 volts, and we have only a 2 per cent. variation. If, however, the near lamps be supplied with 102-volt lamps, and the far ones with 98-volt lamps, it will be seen that we can double the distance, with of course double the fall of pressure, giving 8 per cent. variation, with only 2 per cent. variation up or down in any lamp. For when few lamps are on, the near and far lamps have the same pressure. The engineer makes this 100 volts, which is − 2 per cent for near lamps, and + 2 per cent. for far lamps. When all the lamps are on, the engineer makes the near lamps 104 volts, or + 2 per cent., and the far lamps 96 volts or − 2 per cent., giving a difference of 8 per cent., and doubling the distance which can be supplied. This method has the advantage of not always using the near lamps above, and the far lamps below, their normal pressure; but I must confess I do not like the idea of supplying different consumers with lamps of different pressure, if it can be avoided without loss of economy.

We have now to consider at what distance from the central station we may supply lamps, so that the fall of potential does not exceed 4 per cent. or 8 per cent. This depends on the pressure required for lamps, and on the size of conductors chosen per 1,000 amperes. Every engineer in designing mains must fix on these points for himself, but in order to fix our ideas, I will take the case of 100 volt lamps, and 1½ square inch per 1,000 amperes. With that size of conductor the loss of pressure with the maximum number of lamps is 3·22 volts per 100 yards of double conductor; 4 per cent. is lost in a distance of 124 yards, and 8 per cent. in a distance of 248 yards; so that this is the greatest distance of a lamp from the central station (according as we supply lamps of the same or different normal pressures to different districts) which is consistent at the same time with economical size of conductors, and with a maximum variation of 2 per cent., up and down, in the pressure supplied to any lamp. From what has been said, it will be seen that in this way of working, the pressure at the station must be constantly regulated, either by the speed of the engines, or by introducing resistance into the field magnet coils. I prefer the latter method, unless the newly invented electrical governors (such as Willans') prove a success.

The above considerations apply to what I call the tree system of laying mains. The trunk of the tree starts from the engine house, and throws off branches, from which twigs spring, and leaf stalks from these, and the lamps are represented by leaves. The above considerations do not apply to cases where feeder mains go from different dynamos, or generally where the pressure in different mains at the station is different. It appears, then, that the tree system is of limited application under the conditions which I assumed, the maximum distance being 248 yards. If, however, we had lamps of 400 volts, the maximum distance (measured, of course, along the line of leads) would be 992 yards. In the tree system we must lead our conductors along the shortest route from each lamp to the central station, and then count the number of lamps supplied, and so determine the section of copper required by each point of the mains. If we connect the ends of the positive twigs and the ends of the negative twigs, we do not alter the flow of current when the maximum number of lamps are on, if the size of mains is chosen for this maximum distribution; but when the consumption is limited, we consume a little more energy in proportion, and the distant lamps are a little brighter. But, considering the uncertainity of estimating the relative consumption in different parts of a district, the distant lamps will probably be better served if the + twigs are joined together, and so with the − twigs. I wish to repeat the statement that, in the tree system, the amount of copper in all parts of the mains is the same as if a separate wire came from every lamp to the station. As a consequence, the engineer must notice that if a plant has been laid down for a certain number of lamps, and it be afterwards desired to extend the boundary of the district, the conductors already laid down are of no use in leading current to the beginning of the extended district. The conductors must be enlarged, or else new mains must be led to supply the newly-added district. The engineer must also use his influence strongly to prevent the natural tendency to take a larger number of lamps in a district of supply than that for which the conductors have been calculated.

It must be acknowledged that the simple tree system, where all the dynamos are connected in parallel with the mains, presents a very serious obstacle in the rapid fall of potential, the maximum distance of a lamp from the station along the line of conductors, consistent with the economical considerations, being 124 yards, if the pressure required for all lamps is the same. In the year 1880 Mr. Edison took out a patent in England (No. 3,880), besides outher countries, in which he gets over the difficulty by using what he calls feeder mains. It is a result which would certainly have been arrived at by any one who thoroughly and intelligently worked out the problem. But, so far as I can discover, he was the first, by a long time, to hit upon this cure for the evil; and I must say that it is interesting to find how thoroughly he had gone into the problem at that early stage of electric lighting, although, in a patent of slightly earlier date, he describes the tree system as being all that is required for electric lighting, and does not notice the fact of fall of potentials as affecting the problem. In the patent cited above, Mr. Edison gives, among other irrelevant matter, two solutions of the theory which I may call the multiple tree system and the network system of laying conductors. I will not follow him in his method of using these systems in practice, because he does not use them to the best advantage. In this case, as heretofore, I will advance with you, by common-sense arguments, to the more perfect types.

(To be continued.)

NOTES ON THE SEAT OF THE ELECTROMOTIVE FORCES IN A VOLTAIC CELL.*

BY J. HOPKINSON, M.A., D.SC., F.R.S.

The following is an expansion of some short remarks I made when Dr. Lodge's paper was read at the Society of Telegraph Engineers:—

I. *The controversy between those who hold that the difference of potential between zinc and copper in contact is what is deduced by electrostatic methods, and those who hold that it is measured by the Peltier effect, is one of the relative simplicity of certain hypotheses and definitions used to represent admitted facts.*

Taking thermoelectric phenomena alone, we are not imperatively driven to the conclusion that the difference of potential between zinc and copper is the small quantity which the Peltier effect would indicate; but by assuming with Sir W. Thomson that there is an electric property which

* Communicated by the author to the *Phil. Mag.* for October.

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may be expressed as an electric convection of heat, or that electricity has specific heat, we may make the potential difference as great as we please without contradiction of any dynamical principle or known physical fact. Let us start with the physical facts, and introduce hypothesis as it is wanted. These are, as far as we want them :—(1) If a circuit consist of one metal only, the electromotive force around the circuit is nil however the temperature may vary in different parts; this, of course, neglecting the thermoelectric effects of stress and magnetism discovered by Sir W. Thomson. (2) If the circuit consist of two metals with the junctions at different temperatures t_1, t_2, then the electromotive force round the circuit is the difference of a function of t_2 and of the same function of t_1. According to Prof. Tait the function is $b(t_2-t_1)\left(T-\frac{t_2+t_1}{2}\right)$, or, as we may write it, $A+Bt_2-C\frac{t_2^2}{2}-\left\{A+Bt_1-C\frac{t_1^2}{2}\right\}$; the series may perhaps extend further, but, according to Tait's experiments, the first three terms are all that are needed.

Now, but for the second law of thermodynamis, we should naturally assume that $A+Bt_2-\frac{Ct_2^2}{2}$ was the difference of potentials at the junction of temperature t_2, and $A+Bt_1-\frac{Ct_1^2}{2}$ at the junctions of temperature t_1; we should further assume that what the unit of electricity did was to take energy $A+Bt_2-\frac{Ct_2^2}{2}$ out of the region immediately around the hot junction with disappearance of that amount of heat, and to take energy $A+Bt_1-\frac{Ct_1^2}{2}$ into the region immediately surrounding the cold junction, with liberation of that amount of heat. Now apply the second law of thermodynamics in the form $\Sigma\frac{q}{t}=0$, and we have

$$A\left(\frac{1}{t_2}-\frac{1}{t_1}\right)-C\frac{t_2-t_1}{2}=0,$$

whence it follows that $A=0$, which may be, and that $C=0$, which is contrary to experiment. The current then must do something else than has been supposed, and the hypotheses differ in expression at least as to what that something else is. The fact to be expressed is simply this: When a current passes in an unequally heated metal, there is a reversible transference of heat from one part of the metal to another, whereby heat is withdrawn from or given to an element of the substance when a current passes through it between points differing in temperature, and is given to or withdrawn from that element if the current be reversed. Sir W. Thomson proved that this follows from the fact of thermo-electric inversions and the second law of thermodynamics, and verified the inference by experiment, his reasoning being quite independent of any hypothesis.

Suppose wires of metals X and Y are joined at their extremities, and the junctions are kept at temperatures t_2, t_1. The observed electromotive force around the circuit is $f(t_2)-f(t_1)$, or within limits, according to Tait, $B(t_2-t_1)-\frac{1}{2}C(t_2^2-t_1^2)$. The work done or dissipated by the current when unit of electricity has passed is $f(t_2)-f(t_1)$, and this is obtained by abstraction of heat from certain parts of the circuit and liberation of heat at other parts by a perfectly reversible process. Let $F(t_2)$ be the amount of heat which disappears from the region surrounding the junction t_2 when unit of electricity has passed from X to Y. Let an element of the wire X have its ends at temperatures t and $t+dt$, and let the quantity of heat abstracted from this element when unit of electricity passes from t to $t+dt$ be represented by $\phi(t)dt$, and let the same for Y be represented by $\psi(t)dt$. By the first law of thermodynamics we have

$$F(t_2)+\int_{t_3}^{t_1}\psi(t)\,dt-F(t_1)+\int_{t_1}^{t_2}\phi(t)\,dt=f(t_2)-f(t_1),$$

and by the second law, since the transference of heat from part to part is reversible,

$$F(t_2)/t_2-F(t_1)/t_1+\int_{t_1}^{t_2}\phi(t)/t\,.\,dt-\int_{t_1}^{t_2}\psi(t)/t\,.\,dt=0.$$

Differentiating we have

$$\left\{\begin{array}{l}F'(t)+\phi(t)-\phi(t)=f'(t),\\ F'(t)/t-F(t)/t^2+\phi(t)/t-\psi(t)/t=0;\end{array}\right.$$

whence

$$\left\{\begin{array}{l}F(t)=tf'(t)=Bt-Ct^2,\\ \phi(t)-\psi(t)=tf''(t)=Ct.\end{array}\right.$$

This really contains the whole of thermo-electric theory without any reference to local differences of potential, but only to electromotive force round a complete circuit. But when we come to the question of difference of potential within the substance at different parts of the circuit, we find that according as we treat it in one or the other of the following ways we may leave the difference of potential at the junctions indeterminate and free to be settled in accordance with hypotheses, which may be found convenient in electrostatics, or we find it determined for us, and must make our electrostatic hypotheses accord therewith.

The first way is that of Thomson, as I understand it. Assume that there is no thermoelectric difference of potential between parts of the same metal at different temperatures, at all events till electrostatic experiments shall show that there is. It follows that we must assume that the passage of electricity between two points of different temperatures must cause a conveyance of energy to or from the region between those points by some other means than by passage from one potential to another. Such conveyance of energy may be very properly likened to the convection of heat by fluid in a tube, for, although convection is in general dissipative, it is not necessarily so, *e.g.*, a theoretically perfect regenerator. Suppose, then, that in metal X unit of electricity carries with it $\int\phi(t)\,dt$ of heat, and in metal Y, $\int\psi(t)\,dt$, this will account for the proved transference of heat in the two metals. When a unit of electricity passes across a junction at temperature t from X to Y, it must liberate at that junction a quantity of heat $\int\phi(t)\,dt-\int\psi(t)\,dt$; but the actual effect at this junction is that heat $F(t)$ disappears; hence the excess of potential at the junction of Y over X must be

$$F(t)+\int\phi(t)\,dt-\int\psi(t)\,dt,\text{ or }A+Bt-\tfrac{1}{2}Ct^2,$$

A being a constant introduced in integration. If, then, we assume a "specific heat of electricity," the actual difference of potential at a junction may contain a constant term of any value that electrostatic experiments indicate.

But the facts may be expressed without assuming that electricity conveys energy in any other way than by passing from a point of one potential to a point of different potential. This method must be adopted by those who maintain that the Peltier effect measures the difference of potential between two metals in contact. *Define* that if unit-electricity in passing from A to B points in a conductor homogeneous or heterogeneous does work, whether in heating the conductor, chemical changes, or otherwise, the excess of potential of A over B shall be measured by the work done by the electricity. This is no more than defining what we mean by the potential within a conductor, a thing we do not need to do in electrostatics. This definition accepted, all the rest follows. Between two points differing in temperature dt the rise of potential is $\phi(t)\,dt$ in X, $\psi(t)\,dt$ in Y; at the junction the excess of potential of Y over X is $F(t)=Bt-Ct^2$.

The second method of arranging one's ideas on this subject has the advantage that it dispenses with assuming a new property of that hypothetical something, electricity; but there is nothing confusing in the first method.

II. The thermodynamics of the voltaic circuit may be dealt with on either method of treatment; in the equations already used, instead of speaking only of the heat disappearing from any region, we have to consider the heat disappearing when the unit electricity passes *plus* the energy liberated by the chemical changes which occur. Consider a thermo-electric combination in which there is chemical action at the junctions when a current passes.

If Gt be the function of the temperature which represents the energy of the chemical reaction which occurs when unit of electricity passes from X to Y across the junction, we have

$$F(t_2)+G(t_2)-F(t_1)-G(t_1)+\int_{t_2}^{t_1}\psi(t)\,dt+\int_{t_1}^{t_2}\phi(t)\,dt=f(t_2)-f(t_1),$$

$$F'(t)+G'(t)+\phi(t)-\psi(t)=f'(t),$$

$$F'(t)/t-F(t)/t^2+\phi(t)/t-\psi(t)/t=0;$$

whence

$$\left.\begin{array}{l}F(t)=)f(t)-tG'(t),\\ \phi(t)-\psi(t)=t\{f''(t)-G''(t)\}\end{array}\right\}$$

If now we proceed on the hypothesis of specific heat of electricity, we are able to make the differences of potentials at the junctions accord with the indications of electrostatic experiments. We are, then, by no means bound in a voltaic cell to suppose that there is a great difference of potential between the electrolyte and the metal because there is a reaction there, for we may suppose the energy then liberated is taken up by the change that occurs in the specific heat of electricity.

III. Adopting the second method of expressing the facts, we may consider further the location of the difference of potential in a voltaic cell. In the case of a Daniell's cell consisting of Cu | $CuSO_4$ | $ZnSO_4$ | Zn, at which junction is the great difference of potential? Dr. Lodge places it at the junctions of the metals and the electrolytes. For this there is really some experimental reason, but without such reason it is not apparent why there may not be a great difference of potential between $CuSO_4$ and $ZnSO_4$. In that case, in an electrolytic cell with zinc or copper electrodes and $ZnSO_4$ or $CuSO_4$ as electrolyte there would exist a small difference of potential between the metal and the electrolyte. Take the latter case, an electrolytic cell of $CuSO_4$, and let us leave out of account the irreversible phenomena of electrical resistance and diffusion. First, let us assume, as is not the fact, that the only change in the state of the electrolytic cell when a current has passed is addition of copper to one plate, loss of copper from the other plate; what could be inferred? Imagine a region enclosing the anode, when a current has passed, what changes have occurred within the region? An equivalent of copper has disappeared from the anode, and that same quantity of copper has departed and gone outside the region. But by our supposition, nothing else has happened barring increase of volume for liquid by diminished volume of metallic copper; there is no more and no less $CuSO_4$ in the region, the same quantity therefore of SO_4. All the work done in the region is to tear off a little copper from the surface of the anode and to remove it elsewhere. If the fact were as assumed it would follow that the passage of the current did little work in the

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passage from copper to sulphate of copper, and consequently that the difference of potential between the two is small. But the fact is other things happen in the cell than increase of the cathode and diminution of the anode. In contact with the anode there is an increase of $CuSO_4$, in contact with the cathode $CuSO_4$ disappears; this is a familiar observation to every one. Reconsider the region round the anode. Assume as another extreme hypothesis that after a current has passed we have in this region the same quantity as before of copper, but more $CuSO_4$; SO_4 has entered the region and has combined with the copper. A large amount of energy is therefore brought into the region, which can only be accounted for by supposing that the electricity has passed from a lower potential in the copper to a higher potential in the electrolyte. The legitimate conclusion is, then, that there is between Cu and $CuSO_4$ a difference of potential corresponding to the energy of combination; and the basis of the conclusion is the simple observation that the copper is dissolved off one plate but remains in its neighbourhood, whilst it is precipitated on the other plate, impoverishing the solution. In other words, it is the SO_4 that travels, not the Cu. Now consider the ordinary Daniell's cell. Is there a substantantial difference of potential at the junction of $CuSO_4$ and $ZnSO_4$? Is there, in fact, a difference apart from the Peltier difference? Imagine a region enclosing the junction in question; it might have been that the effect of a current passing was to increase the zinc and diminish the copper by an equivalent of the electricity which passed, from which we should have inferred that the seat of the electromotive force in a Daniell's cell was at the junction of the two solutions. But it is more nearly the fact that no change whatever occurs in the region in question when a current passes, and that all that happens is that a certain quantity of SO_4 enters the region and an equal quantity departs from it, from which it follows that there is no potential difference, other that a Peltier difference, at this junction.

Neither of the extreme suppositions we have made as to concentration or impoverishment of the solution is in fact true, but they serve to show that the position of the steps in potential depends entirely on the travelling of the ions. The fact is that in general both ions travel in proportions dependent on the condition of the electrolytes; it is probable that the travelling of the SO_4 depends on some acidity of the solution. Given the proportion in which the ions travel and the energy of the *reversible* chemical reaction which occurs, and we can calculate the differences of potential at the junctions.

In the preceding reasoning an assumption has been made, but not stated. It has been assumed that the passage of a current in an electrolyte is accompanied by a movement of ions only, and not by a movement of molecules of the salt; that is, when unit of electricity passes through a solution of $CuSO_4$, xCu travels in one direction and $(1-x)SO_4$ in the opposite direction, but that $CuSO_4$ does not travel without exchanges of Cu and of SO_4 between the molecules of $CuSO_4$. In the supposed case when there is no concentration around the anode, my assumption is that Cu is dissolved off the anode, and that an equal quantity of Cu leaves the region around the anode *as Cu* by exchanges between the molecules of $CuSO_4$. But it is competent to some one else to assume that in this case SO_4 *as* SO_4 enters the region by exchanges between the molecules of $CuSO_4$, and that at the same time a molecule of $CuSO_4$ leaves the region without undergoing any change. Such a one would truly say that there was no inconsistency in his assumption; and that if it be admitted, it follows that the difference of potential at the junction $CuSO_4 \mid Cu$ is that represented by the energy of the reaction. I prefer the asssumption I have made, because it adds nothing to the ordinary chemical theory of electrolysis; but it is easy to imagine that facts may be discovered more easily expressed by supposing that an electric current causes a migration of molecules of the salt, as well as a migration of the components of the salt.

COMPANIES' REPORTS.

Brazilian Submarine Telegraph Company (Limited).

Report and accounts of the Directors for the half year ended 30th June last, to be submitted to the twenty-fourth ordinary general meeting, to be held at the Cannon-street Hotel, on the 29th inst., at two o'clock:—

The revenue for this period amounted to £81,419. 10s., and the working expenses to £19,774. 0s. 11d. (including £7,830. 7s. 3d. for repairs of cable). After providing £9,680 for debenture interest and sinking fund, and £927. 9s. 4d. for income tax, there remains a balance of £51,037 19s. 9d.; to this is added £2,792. 16s. 6d., brought forward from 31st December last, making a total of £53,830. 16s. 3d. A quarterly interim dividend amounting to £19,500 has been paid, and £12,000 transferred to the reserve fund, leaving a balance of £22,330. 16s. 3d. The directors now recommend the declaration of a final dividend of 3s. per share, making a total payment of 6 per cent. for the year ended 30th June, 1885, and that the balance £2,830. 16s. 3d. be carried forward to the next account. The various sections of the Company's line are in good working order, with the exception of the Madeira-St. Vincent 1874 cable, in which a fault appeared on the 12th September. This, however, does not interfere with the regular transmission of traffic by that cable. The Directors regret to announce the recent death of Senor Santos Silva, the Company's representative director in Lisbon. They have, under the powers given them by the Articles of Association, elected the Duke de Loulé to fill the vacancy thereby occasioned. Two of the directors, the Duke de Loulé and the Right Hon. Viscount Monck, retire by rotation at this meeting, and being eligible for re-election, offer themselves accordingly. The two auditors, Mr. Henry Dever and Mr. John Gane, also offer themselves for re-election.

Direct Spanish Telegraph Company (Limited).

Report of the Directors for the half year ended 30th June last, to be presented at the general meeting of the shareholders, on Friday, October 30th, 1885:—

The accounts for the half year ended 30th June, 1885, show, after providing for debenture interest, a balance to the credit of profit and loss of £3,469. 12s. 10d. The traffic receipts show a falling off of £1,384. 6s., as compared with the corresponding half year of 1884, and a decrease of £823. 17s. 3d. as compared to last half year. This unsatisfactory result is due to the stagnation of trade with Spain during the period for which the accounts are presented. The Directors having been unable to obtain a suitable steamer at a moderate cost during the summer months, the overhaul of the original Bilbao cable has been postponed. The new Bilbao cable and the Marseilles-Barcelona cable worked perfectly during the half year. Unfortunately, on 11th inst., an interruption of the new Bilbao cable occurred in deep water, about 70 miles from Bilbao. Arrangements have been made for a cable ship to proceed to the spot and effect the repairs. The Directors would remind the shareholders that the joint purse arrangement with the Eastern Telegraph Company secures to this Company during the interruption a revenue nearly equal to that earned when the Bilbao cable route is open. As the circumstances mentioned by the Directors in their circular of the 14th January last, embodied in the Directors' report adopted at the last general meeting, still exist, they must continue to withhold the payment of dividend on the preference shares, and they therefore propose to put £3,400 to the reserve fund, which will then amount to £8,400, and to carry £69. 12s. 10d. to the next account. At the International Telegraph Conference recently held at Berlin, all European telegraph administrations and private cable companies had to submit to certain reductions in their tariffs. In the case of this Company it is anticipated that the effects of these will be counterbalanced by a development of the traffic and by the reduction in the inland rates at both ends. The new regulations of Berlin come into force on 1st July, 1886.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Oct. 21.		Business Done Week Ending Oct. 21. Highest.	Lowest.
Anglo-American	32,	33	32½	30½x.d.
Do. Preferred	53½,	54½	54½	51½x.d.
Do. Deferred	8¾,	9½	8 13-16	8¾
Brazilian Submarine	11⅝,	11¾	11½	11⅜
Cuba	12,	12½	12	—
Do. Preference	18,	19	18¾	—
Direct Spanish	1½,	2	—	—
Do. Preference	11½	12	—	—
Direct United States Cable	9½,	9¾	9½	8¾x.d.
Eastern Telegraph	11½,	11¾	11¾	11 7-16x.d.
Do. 6 per Cent. Preference	13¾,	14½	13¾	13¾x.d.
Do. 5 per Cent. Debentures, 1899	105,	108	105½	—
Eastern Extension	12½,	12¾	12¾	11¾x.d. &
German Union	9½,	9¾	9 11-16	—(bonus
Globe Telegraph and Trust	6¾,	7¼	7¼	6¾x.d.
Do. Preference	13½,	13¾	13 5-16	13¼x.d.
Great Northern	13½,	14	14¼	13¾
Indo-European	31,	32	—	—
Reuter's	7½,	8	7¾	7¾
Submarine	205	215	213	207
West India and Panama	⅝,	¾	11-16	⅝
Do. 1st Preference	8½,	8¾	8¾	8¾
Western Brazilian	5½,	5¾	5¾	—
Western Union 7 per Cent. 1st Mortgage	120,	124	124	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅞,	1	15-16	—
Oriental	3-16,	5-16	—	—
United Telephone	11¼,	12½	12¾	11¾

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1⅞,	2¼	2¼	2 1-16
Do. (fully paid)	3½,	4½	3¾	—
Hammond Light (£3 15s. paid)	1-16	3-16	⅛	5-16
Swan	½,	¾	¾	—
Maxim-Weston	3-16,	5-16	—	—

MISCELLANEOUS.

Telegraph Construction	36,	37	37	36½
India Rubber, Gutta Percha, and Telegraph Works	23½,	24½	24½	24

TRAFFIC RECEIPTS FOR SEPTEMBER, 1885.

Companies.	Sept., 1885.	Sept., 1884.	Increase.	Decrease.
Brazilian Submarine	—	—	—	—
Cuba Submarine	2,100	2,163	—	63
Direct Spanish Telegraph	1,770	1,603	167	—
Eastern Telegraph	47,849	50,913	—	3,064
Eastern Extension	41,845	41,590	255	—
Great Northern	25,200	—	—	—
West Coast of America	3,680	—	—	—
Western and Brazilian	—	—	—	—

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NOTES.

THE ANTWERP EXHIBITION.—This Exhibition will be closed on the 1st prox.

THE TELEGRAPH IN SIAM.—Information has been received that the Siamese Government have completed the telegraph line from Bangkok to Rahung.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 23rd inst. amounted to £3,137.

ELECTROLYSIS.—Dr. D. Tommasi has recently made public some very interesting notes upon the phenomena attending the electrolysis of hydrate of chloral.

A NEW GALVANOMETER.—We are informed that M. Félix de Lalande is about to lay before the members of the Académie des Sciences a galvanometer upon an entirely new principle.

STRUCK OFF THE REGISTER.—From Tuesday's *London Gazette* we notice that the Electric Engine Company (Limited) has been struck off the register of Joint Stock Companies, and is thereby dissolved.

UNDERGROUND WIRES IN DETROIT, U.S.A.—The work necessary for putting telegraph, telephone, and electric light wires underground in Detroit, Mich., began 29th September. The Dorsett conduit is being used.

A GOOD CUSTOMER.—From *Australian Information for British Journalists* we notice that during the past year no less than 17,512 packages of telegraphic materials were sent to New South Wales from this country.

EARLY!—According to the *Bulletin International des Téléphones* French scientists are rather more given to early rising than their English brethren. On the 26th and 29th inst. two conferences were held in the Exposition du Travail at half-past nine a.m.

CARRIAGE LIGHTING BY ELECTRICITY.—The Lancashire and Yorkshire Railway Company are still experimenting with the electric light for the lighting of their carriages, but will not be able to come to any conclusion on the matter in time for the coming winter.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 23rd October, were £2,424, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE TELEPHONE IN FRANCE.—The telephone system at Saint Etienne, due to the enterprise of the Société Générale des Téléphones, was opened for traffic on the 15th inst., with a list of 26 subscribers. In this system overhead insulated wires have been used.

ELECTRICITY V. GAS AT BRUSSELS.—The two illuminants are in active dispute at Brussels, the bone of contention being the lighting of the Grand Place. The Municipal Council of Brussels are sorely perplexed, but gas will, in all probability, have to take second place.

ELECTRO-THERAPEUTICS IN FRANCE.—An important instal lation, devoted to the service of electro-therapeutics, has been put down in the Salpêtrière Hospital at Paris by the Maison Breguet. This consists of two Carré electrostatic machines, actuated by a Gramme dynamo placed some two hundred yards distant.

QUITE RUSSIAN.—An Electrical Exhibition is to be held in St. Peterburg from the coming month until February, 1886. Foreign exhibits are not to be permitted. The show will probably, therefore, be restricted to the wonderful motor we have heard so much about, and the still more wonderful Stépanoff battery.

A COURSE OF SCIENCE LECTURES.—An important series of science lectures was commenced on the 16th inst. at the Memorial Hall, London-street (near Bethnal Green Junction), and will be continued every Thursday. Yesterday the lecturer was Prof. Guthrie, F.R.S., and the subject "Electricity." The price of admission is a mere trifle.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—At a meeting of the directors of this company, held on the 28th inst., it was resolved to place £6,000 to reserve, and to recommend to the shareholders at the approaching meeting that a dividend of 9s. per share be declared on account of arrears of dividend on the first preference shares.

CABLES FOR ITALY.—We are informed that a contract for a submarine telegraph cable to be laid from Naples to Palermo has been concluded between the Italian Government and the firm of Pirelli and Co., of Milan. The maintenance of this line is estimated at about 80,000 lire per annum. It is said that all the islands on the coast are to be similarly connected.

PERSONAL.—Mr. E. W. Parsone (the manager of the West African Telegraph Company) left England in the R.M.S. "Tamar," on Saturday last, to assume his duties at Praia St. Thiago, Cape de Verde Islands. He is accompanied by Mr. Reginald Webb (the assistant accountant), and Mr. A. Kitching (the superintendent of one of the company's stations).

THE EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY.—This company notify that the coupon on their 5 per cent. Manila Debentures (June, 1880), due on the 1st November proximo, will be payable on and after that date on presentation of the same at the Consolidated Bank, 52, Threadneedle-street, E.C. Coupons should be left three clear days for examination.

TELEPHONIC COMMUNICATION IN BOURNEMOUTH AND POOLE.—The Western Counties and South Wales Telephone Company are progressing with their arrangements for supplying telephone communication for domestic and commercial purposes in Poole and Bournemouth. It is proposed to connect the police station and the dispensary at Bournemouth with the central office, free of charge. The fire stations will also be connected.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.—This company notify that the 21st distribution on the certificates of the second bonus trust, issued under the trust deed of the 12th March, 1875, will be made on and after the 2nd November, 1885. The distribution will be at the rate of 1s. 1d. per £5 certificate, payable two clear days after presentation of coupon No. 21, at Messrs. Barclay Bevan and Co.'s Bank, 54, Lombard-street.

THE STEPANOFF PRIMARY BATTERY.—Glowing accounts are being given of the Russian modification of the Daniell, called the Stépanoff cell. For electric lighting purposes the battery is said to consist of 55 elements, comprised within a space of 55 cubic decimètres. These are said to be sufficient to supply 10 45-volt Jablochkoff lamps for a period of 120 hours. The cost is estimated at 10 per cent. less than that of gas at St. Petersburg. Hum!

H.M.S. "DEVASTATION."—The "Devastation," Captain Luxmoore, left Portsmouth Harbour, and anchored at Spithead

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on the morning of the 27th inst., preliminary to superseding the "Lord Warden" as coastguard ship at Queensferry. Since her return from the cruise of the Evolutionary Squadron she has had her bunkers ventilated upon a new principle, and has been fitted with dished torpedo ports—for the purpose of keeping out the water—and also with the electric light.

LIGHTING OF REGENT-STREET.—At a recent meeting of the St. James's Vestry, Westminster, Mr. A. Keevil called attention to the wretched system of lighting which existed in Regent-street. He said several of the lamps had been there for considerably over half a century. They were in a wretched state of dilapidation, and a disgrace to the parish. Mr. R. W. Burgess explained that the Lighting Committee were in communication with the West London Electric Lighting Company as to lighting the street by electricity.

THE ELECTRIC LIGHT IN THE TEMPLE.—The Inner Temple Library was lighted by the electric light for the first time on the evening of the 26th inst. About 140 small lamps are employed, the system in operation being the Swan-Edison. The engine house is situated near the Inner Temple lecture hall in King's Bench-walk, and the engine for generating the light is a twelve horse-power one. As oil lamps only have hitherto been in use in the library, the change effected by the substitution of the electric light is peculiarly striking.

BOOKS RECEIVED.—"High School Science Series. Lectures on Heat, Sound, and Light," an elementary text-book for students. By Richard Wormell, D.Sc., M.A. London: Thomas Murby.—"Etudes Electriques et Mécaniques sur les Corps Solides. Conférences by Lazare Weiller." Paris: J. Michelet.—"Die Internationalen Absoluten Maasse, insbesondere die Electrischen Maasse; für Studirende der Electrotechnik." By Dr. A. von Waltenhofen, Professor of the Technical High School, Vienna. Braunschweig: Frederich Vieweg and Son.

THE ELECTRIC LIGHT IN SWEDEN.—Owing to the great height of water lately in Ljusne river, floating has temporarily been suspended in the lower river, and picking out the logs to be drawn on land for winter sawing at Ljusne saw mill could not, in consequence, be proceeded with, for which reason now, to make up for lost time, having first tried torches to get sufficient light at the timber booms, the electric light has been carried from the saw mill, and been found especially suitable, as it not only considerably lightens the labour, but also enables it to be done with greater safety.

PERSIAN GULF CABLE.—The cable steamer "Dacia," with Colonel Champain and Sir Henry Mance on board, arrived at Port Said on the 23rd inst., and the "International" arrived there on the 27th inst., all well. These vessels proceeded to Yask (Persian Gulf), where they are expected to arrive about the 21st November. Immediately on their arrival the laying of the new Persian Gulf cable will be commenced, under the personal superintendence of Colonel Champain, R.E. We understand that a slight collision occurred between the "Dacia" and another vessel in the Canal.

SHAM LEATHER.—An electrical process for the imitation of leather surfaces has recently been described. The leather which it is desired to imitate is first well cleaned and coated with graphite, as in electro-plating a smaller article. It is then placed in a copper bath, the tank of which is large enough to receive easily a skin of any size. A dynamo generating a powerful current furnishes the electricity. The copper is deposited upon the coated surface of the hide to a thickness of one-sixteenth to one-eighth of an inch. The plate thus formed reproduces, but reversed, every mark and minute vein of the leather, so that a print can be easily taken from it.

THE TELEPHONE AT GREENOCK.—In connection with a series of lectures which are being delivered in Greenock under the auspices of the Philosophical Society of that town, Mr. W. Lant Carpenter, B.A., F.C.S., manager of the School of Electrical Engineering, London, delivered the third of the course, "The Telephone," in the Town Hall, which was crowded to its utmost capacity, about 3,000 persons being present. In the course of his lecture Mr. Carpenter opened communication with the *Glasgow Herald* office, where a party of ladies sat listening to the lecture through the telephone, every word of which was heard with the greatest distinctness. In the Glasgow National Telephone Exchange the lecture was also well heard.

THE ELDORADO THEATRE, PARIS.—The Eldorado is at the present moment the only theatre in Paris entirely lighted by electricity, and this is rendered more remarkable in that Cance arc lamps are alone used. It is the only instance, with which we are acquainted, of a theatre possessing an installation excluding both the incandescent lamp and gas. The mechanical section of the plant comprises an Olry and Grandmange 40 horse-power steam engine and a powerful boiler. The dynamos, a series of small machines, are of the Gramme type, manufactured by the firm of Ducommun. Each of these gives a current of from 35 to 40 amperes, with a difference of potential at the terminals of from 55 to 70 volts, which is distributed between five lamps in multiple arc; 35 Cance arcs are included in the system.

TELEGRAPH POSTS AT BOURNEMOUTH.—At a recent meeting of the Bournemouth Improvement Commissioners, some discussion took place on the subject of a letter from the Telegraph Department of the General Post Office as to the substitution of underground pipes for the present wooden posts in the Bournemouth district. The letter stated that the department were preparing for the laying of pipes between the two railway stations, but a member of the commission moved that the clerk should be instructed to inquire whether the authorities would be disposed to continue the underground pipes throughout the whole of the commissioners' district, especially calling attention to the necessity of the scheme being carried along the Poole road, where at present the poles interfered with the foot traffic. The proposal was agreed to.

THE TELEPHONE SUITS.—The Orange, N. J., *Chronicle* says:—Prof. J. R. Paddock, of the Stevens Institute, has been engaged the past summer in important investigations as expert for the Overland Telephone Companies of New Jersey and Pennsylvania, in the suits pending in the United States courts for infringement of Bell's patents. The defence rests in part upon the inventions of Philipp Reis. Prof. Paddock received some time since the *original instruments of Philipp Reis* from Frankfort, Germany, and has been engaged with E. W. Smith, of New York, in testing their efficiency as regards this much disputed point. They have proved, we are informed, that the *identical telephone used by Reis at his lecture in* 1861 will transmit speech without any alteration. They stated that they had used it in Prof. Paddock's laboratory on a line from the house to the stable, 350ft, and had succeeded in sending many words and short sentences and the words and music of various songs.

ZINC MANGANESE BATTERY.—In some experiments with Leclanché batteries, Dr. Emil Boettcher used for the negative

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element plates consisting of 40 per cent. of retort carbon. 55 per cent. of manganese, and 5 per cent. of binding medium, the whole being combined under a hydraulic pressure of 200 atmospheres. The dimensions of the plates were 12 centimetres long, 4·2 centimetres wide, and 2 centimetres thick. The electromotive force of a cell composed of such a plate, and an amalgamated zinc rod in a solution of sal ammoniac was 1·56 volt. From a calculation of the quantity of heat generated and absorbed by chemical action in a battery of this kind, Dr. Boettcher concluded that sulphuric acid would give a better result than the solution of ammonic chloride, provided a counter electromotive force was not set up in consequence of the formation of manganous sulphate and liberation of oxygen; but no such opposing force was manifested, although manganous oxide was dissolved. The electromotive force was 2·2 volts, or almost 50 per cent. higher than that of a Leclanché battery, in which a solution of sal ammoniac forms the exciting liquid. After remaining on short circuit for six hours, the cell gave 2·1 volts, and at the end of seventy-six hours, the electromotive force was rather more than 1 volt.—Abstracts *Proc.* Inst. C.E.

THE COLCHESTER INSTALLATION.—It is said that the South-Eastern Brush Electric Light and Power Company have resolved to liquidate, and to dispose of their works at Colchester, if possible. This has not yet been done, but there is some reason to believe that unless the subject is promptly taken up by Colchester people, the whole plant will be removed; the City of London, as well as an American city, says an Essex contemporary, being said to be in treaty for the purchase of the undertaking. The district covered by the license comprises High-street, Head-street, and Culver-street, Colchester. The plant already in position comprises the street works and conductors, sufficient for the supply of about at least 2,200 lamps of present character as to consumption of current. A central station in Culver-street is fitted with a steam engine (by Davey, Paxman and Co.), dynamo machines, and all necessary appliances for the generation and distribution; and five storage battery stations situated in Culver-street, Head-street, and High-street, are fully equipped with accumulators, rocking switches, &c., upon the B.T.K. system, and capable of supplying current for about 1,000 lamps. The cost of the plant amounts to about £8,000, but by arrangement with the vendor company it is said that the whole would be transferred to a new company or other purchaser for the sum of £1,500.

SENSITIVE.—Our gas lighting contemporaries cannot find much that is true to say against our favourite illuminant. They, however, display at times a good deal of ingenuity—in fact—twisting—in order to be able to arrive at conclusions which agree with the interests they represent, and which are therefore inimical to those of electric lighting. In view of this, it is refreshing to find that at least one of our contemporaries is sensitive, even to criticism of a much milder type Commenting upon an article recently published upon Dr. Schilling's report upon lighting in Germany, it says that the position of the writer "respecting gas lighting is similar to that of the Ancient Romans to geography, as described by Mark Twain. He declared that the 'knowledge' of the physical world which they 'did not possess was very extensive.' At least it does not lie in the mouth of a writer of this order to find fault with Dr. Schilling, or any other gas engineer, for seeing more of the weaknesses than of the excellences of electric lighting." To admit any one of the excellences of the electric light would certainly be absurd in a gas engineer. With nothing but faults apparent the light is quite formidable enough as a rival. Argument is, however, unnecessary. We only wish to point out that our gas contemporary is in the position of the small boy who, having repeatedly attacked a more powerful one and eventually provoked a return, plaintively remarked "it hurts!"

WEST AFRICAN CABLES.—The cable steamer "Silvertown" arrived at Dakar, Senegal, on the 22nd inst., and landed the Dakar shore end on the 24th inst.; her tender, the "Buccaneer," arrived at Teneriffe, after a voyage of five days, from England, on the 24th inst., and was expected to reach Dakar yesterday, the 29th inst., where she would join the former vessel. Laying of cable will be proceeded with at once, connecting up Dakar with Conakry (French possession near Sierra Leone), St. Louis du Sénégal, Bolama, Bissao, and St. Thiago in the Cape de Verde Islands. So soon as permission to land has been accorded by H.B.M.'s Government, the West African Telegraph Company intend connecting up Bathurst and Sierra Leone, and to give those colonies the benefit of duplicate communication with England, first through the lines of the Brazilian Submarine Telegraph Company and the Eastern Telegraph Company, and secondly through the lines of the Spanish National and Direct Spanish Telegraph Company. The "Buccaneer," on completion of the cable laying to Conakry, or Sierra Leone, will proceed to thoroughly sound and reconnoitre, as far as St. Paul de Loanda, the ground over which the extensions of these lines will be laid. The English Government are sending out the surveying vessel "Sylvia" to the west coast of Africa especially for the determinations of longitudes of various points along this coast, and the West African Telegraph Company have placed the cables already laid and those in process of laying at the disposal of the Hydrographer to the Admiralty. This vessel leaves at the end of the present year.

WHITEHAVEN SCIENTIFIC ASSOCIATION.—At a *conversazione* recently given by this society there was an interesting display of scientific apparatus. The National Telephone Company exhibited a large collection of telephonic instruments, amongst which were samples of the early telephones of Reis, Edison, and Dolbear. The company had also connected the hall to their Whitehaven Telephone Exchange, through which the guests were able to converse during the evening with Frizington, Workington, and Maryport. At the last-named town a violin player was stationed, whose strains were distinctly audible in Whitehaven, notwithstanding that a distance of fourteen miles separated him from his audience. Towards the finish of the evening Mr. Alfred R. Bennett, general manager of the National Telephone Company, gave a historical sketch of the telephone. He referred to traditions of such an instrument having existed long ago amongst the Chinese and Persians, and read a translation of an anonymous letter addressed to Comte du Moncel in the year 1857, the writer of which not only expressed his belief in the possibility of transmitting speech by electricity, but in stating how he thought the feat might be accomplished he actually described in its essential details the telephone which was used to day in West Cumberland and all the chief cities of the earth. Mr. Bennett then described the mechanical telephone, and the inventions of Reis, Varley, Elisha Gray, Paul Lacour, Graham Bell, Hughes, Dolbear, and Edison, as well as the modification of the Hughes-Bell telephone designed by Mr. Gower, whose death he alluded to in feeling terms. The description of each instrument was illustrated with the actual apparatus.

TELEPHONING FROM LIGHTSHIPS.—An experiment of the greatest importance to the commercial world is now being made on the east coast of England by the Telegraph Construction and Maintenance Company. For the last eight months

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the company has had several of its best operatives located in the neighbourhood of the Naze, off which the most dangerous sands round England are to be found. These gentlemen are hourly in communication by telephone with a lightship which is anchored ten miles out in the vicinity of the Swin passage. An ordinary telegraph cable has been laid from Walton-on-the Naze to the Sunk Lightship, and telephone and telegraphic apparatus have been affixed to both ends. It was considered improbable that the human voice would be conducted 10 miles, especially in rough weather; but this has been now proved to be thoroughly practicable. A conversation was carried on with Mr. Stevenson, one of the Telegraph Maintenance Company's officials (who was on board the Sunk Lightship) by telephone for a considerable time. Mr. Stevenson had been a month upon the boat, and had experienced all kinds of weather, during which time he had kept Mr. Lewis and Mr. Pinkerton, his colleagues on shore, fully informed of the state of the weather, roughness of the sea, and passing craft, adding frequently forecasts of weather, which usually turned out to be correct. A month upon the lightship is a trying ordeal; but Mr. Stevenson was so satisfied with the success that attended the experiment, and knowing, if the advantage of telephonic communication with lightships was understood and generally adopted, what a splendid boon it would be to mariners and merchants, that he spent his time busily in collecting information and watching the working of his electrical machines.

Telephone Rates.—A correspondent of the *Yorkshire Post* writes as follows:—"The rates charged by the National Telephone Company are simply prohibitory for the multitude. I saw an account of a meeting held in Leeds recently, under the auspices of the Leeds Chamber of Commerce, and the chairman of the company explained why rich physicians, lawyers, and prosperous fishmongers, &c., should have a reduction of £5 made in their rates over the charge of £15 made to merchants, ironmongers, &c. I cannot understand the sense of this dual rate. It is utterly beside the question to say that doctors and other professional men do not transact business by 'telephone.' They make appointments, and save time and money. Why, I have heard doctors say that the telephone is indispensable to them, and saves them the cost of a horse's keep. The thing is simply monstrous. Englishmen don't like being unfairly dealt with, and rather than be subjected to an extortionate charge hundreds of business people do without the telephone. If the thing cannot be supplied for a less rent than £15, how is it that professional men have it at £10? It naturally strikes one that the company make money out of the lower rate, or they would not supply the professional gentlemen at the price. If so, why not make all £10, and they would get hundreds of new members? If they cannot afford to do this, make all pay £15. I mix a good deal with people who are interested in the matter, and am sure that until this unfair system of favouring the rich professions is abolished the thing will not prosper. I am afraid that our only hope is that Government will take the telephones, as in Germany, and serve the public in as liberal a spirit as they do the telegraph."

The Creil Experiments.—M. Marcel Deprez has been experimenting with two new dynamos connected through a resistance equal to that of the cable between Paris and Creil. The results are said to be satisfactory. At a sitting of the Académie des Sciences on the 26th inst., M. Marcel Deprez communicated the result of some experiments made between Creil and La Villette over a distance of fifty-eight kilometres for the electrical transmission of power. M. Deprez stated that complete success was obtained, inasmuch as he had effected the transmission of forty horse-power out of eighty over the line without the current heating the wire or the machine. The costs of the experiment were defrayed by M. de Rothschild. M. Marcel Deprez's public experiments, between Creil and Paris, will take place in November. Two dynamos will be set in motion and several arc lamps lit by a current sent from Creil. As it was judged unsafe to have the earth as part of the circuit, there are two copper conductors hung 19ft. above the ground, which, to suit the somewhat exacting requirements of the telegraph office in view of the public safety, are coated with india rubber. The resistance of the line is 120 ohms; its insulation is absolute. In the preliminary experiments which took place the generator and receptor were placed side by side at Creil, and connected by a copper cable going to Paris and back. The generator can develop 6,000 volts and 30 amperes for 150 revolutions per minute. The force is supplied by two old locomotives, the wheels of which are replaced by flywheels. It is a remarkable feature of the dynamos that there are no sparks whatever at the collector, notwithstanding the high electromotive force. M. Alphonse de Rothschild has spent a large sum to enable M. Deprez to apply his theories at Creil, assisted by a select staff of engineers.

Multiple Telegrams.—A correspondent of the *Standard* says:—"I had occasion recently to send off one message to a number of addresses. As four of these lay within the same postal district, I proposed to send them as a 'multiple telegram,' which under the old tariff I could do for threepence per message for each address after the first. I asked the young lady presiding at the telegraph office whether any change had been made, and she, after consulting a book, informed me that the charge had been reduced to twopence per address. Pleased at this unexpected concession, I paid my money and left; but my satisfaction was somewhat dashed next morning when a messenger called at my house to say a mistake had been made, and that they wanted sevenpence more. In return for the extra sevenpence I asked to see the regulations under which I was (by the cheaper tariff) called upon to pay thirteenpence for what, under the old system, would have cost ninepence. I was handed a paper headed 'Multiple Telegrams,' which began, 'To simplify, &c.,' and then followed a full page of instructions and examples, the upshot of which was that 'all the words in all the addresses were to be added to the original message, and charged for, and then an additional charge of twopence per address was to be made for each one after the first.' The working of this arrangement is that registered addresses may pass at the old scale, but all ordinary addresses will cost from 50 to 100 per cent. (according to the number of words in the address) more than formerly. To the official mind it may be the acme of simplicity to substitute for the three words 'threepence per message' a page of instructions, which serve only to bewilder their own clerks, but I doubt whether it is worthy of a large 'Department' to adopt such a roundabout way of mulcting the public of a few extra pence; and to an ordinary intelligence it does look like (as the telegraph clerk expressed it to me) 'charging twice over.'"

Underground Wires.—According to a paper read by Mr. W. W. Jacques, before the Boston Society of Arts, the first telegraph line constructed in America, from Baltimore to Washington, in 1843, was intended to be laid underground, and the first nine miles were so laid. Four copper wires were each wound with cotton soaked in shellac, and the whole drawn into a lead tube. This tube was laid in a trench by the side of the railroad. Hardly was the section completed,

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however, when water found its way into the joints, destroying the insulation, and the conductors failed. They were accordingly replaced by wires strung on poles, and the rest of the line was constructed in this way. After the introduction of gutta percha in 1846 many systems were tried, and after repeated failures the result is that there now exists a successful and durable system of underground telegraph wires connecting the principal cities of Germany and of France. In Paris not only all the telegraph lines, but also those for electric lights, telephones, and other purposes are carried through the sewers. Between 1847 and 1850 a system of cables was laid under ground between Berlin and other cities of Prussia. Gutta percha covered wires were drawn into lead tubes, which were buried in trenches two feet deep. In 1853 the entire system had been replaced by pole-lines. Somewhat similar cables were laid in Russia, France, Denmark, and England, but all, with the exception of those laid in the sewers of Paris, were unsuccessful. The trouble with all these systems was due to water, which destroyed the insulation. In 1855 the experiment was tried in France of laying bare wires in a trench filled with bituminous compounds, but the system failed. Since 1870 several lines have been built in England, Germany, and France, which have continued to work successfully. In Germany successful underground cables connect all the principal cities of the empire, while in France there is a system, dating from 1880, which connects Paris with all of the more important cities of that country. In the present German system, which dates from 1875, the cable is composed of seven copper wires, each coated with two layers of gutta percha and two of Chatterton's compound, and the whole covered with an armour of galvanized iron wires. This is laid in a trench by the roadside. The present French system was begun in 1880, and consisted of cables of gutta percha covered wires which are drawn into iron pipes three or four inches in diameter, and buried along the side of the road.

THE TELEGRAPH AND TELEPHONE IN COLUMBIA.—The first line of telegraph constructed in this country was that of the Panama Railroad Company. In the year 1865 the first National Telegraph line was constructed by a Mr. Styles, of New York, and up to that date there were five distinct National lines starting from the capital (Bogotá) covering a distance of 3,940 kilometres, and which put in communication 120 towns. One of these lines puts the capital in communication with the cable station at Buena-Ventura on the Pacific coast, another goes down towards the Atlantic coast, but is not yet complete. It would have been done ere this, but during the last twelve months there has been civil war. For most parts where the lines pass it is not very difficult to obtain splendid wood for posts. The class of insulators used are Siemens' iron hooded, and the instruments are Chester and Breguet manufacture, and are of the writing system. The alphabet used is of the American Morse system. With the exception of the State of Antioquia and the Atlantic coast, where the shut-circuit system is employed, all the lines work upon the open-circuit system. One of the lines puts Venezuela in communication with the capital. There are fifteen translating offices, which is a greater number than there is necessity for. The number of batteries in use in each office ranges from 30 to 100, much too great a number, but this in time will be regulated. The class in use is the Leclanché. When the telegraphs were first introduced into the country the priests preached against them, and they were constantly being destroyed, until the Government took strong measures to stop this barbarism. During this war all the lines have been more or less destroyed; but the Columbian Telephone Company have been able, at a tremendous outlay, to get them in order again. Columbia stands fourth in the list for length of line in S. America. There are two telephone companies there. The one in Barranquilla is the American Bell Company, which has about 50 subscribers. This was the first telephone company in the country. The other is in Bogotá, and is a native company, which, though not in existence a year, has over 100 subscribers, and but for the war would have had more than double the number. Both these companies use the Bell telephone, with Blake transmitter system. Besides these two companies the telephone is in use on four railroads, and also in several of the mines. The Inspector-General of Colombian Telegraphs and engineer to the Colombian Telephone Company is Mr. Ernest Danvers.

THE PITMAN AND THE TELEPHONE.—At one of our Northumbrian pits lately, the telephone has been laid into the clerk's office. As a matter of course, the introduction of such a wonderful piece of machinery created a no small amount of gossip in the district, and the powers of the instrument were exaggerated by the good people of the village to an enormous degree. A well-known pitman, noted for his inquisitiveness, made overtures to the office boy to allow him to have a try at the telephone. A Saturday afternoon was fixed (of course when the coast would be clear) for the trial, and Geordy was ushered into the presence of the mysterious box and tubes. "Stand heor," said the boy, pressing the white knob, "an aa'll ring the beggors up at Newcastle. Tyek haad o' these tubes, and taak when ye heor the bell ring." Presently the bell began to tinkle, and Geordy with a tube in each hand seemed to be puzzled over something. The bell kept on ringing. "Gan on, man; taak," said the boy. Geordy put one of the tubes to his mouth, and shouted with all his might, "Stop that bell." "Get oot, ye feuyl," exclaimed the boy, "taak into the box." "Hoo on airth can aa taak into the box when the lid's on't?" excitedly said Geordy. Still the bell rang on ringing. "Oh, dear me," gasped the youth, "what ignorance! Ye hev to had yor mooth ower the box and taak." "Haad the pipes te yor lugs, ye donkey!" shouted the boy, "or hoo'll ye heor?" Geordy did as he was told, and he distinctly heard, "Are you there? How much longer are you going to be?" Geordy, astonished, looked under the box, and then said, "That box is far ower little te haad onybody, or else he mun be a varry little chap that's in't." "There's somebody knockin' at the door," said the boy, "aa'll away doon and see we it is, ye knaa hoo te de noo. Aa'll be back doreckly." Geordy again placed the tubes to his ears and again he heard the words, "Are you there? What r-l-l-r-do-r-l-l-you-r-lr-want?" Geordy was somewhat puzzled at this last question, and more particularly at the rumbling sound he heard; an idea, however, struck him, and the following conversation ensued:—Geordy: "Wheer are ye?" Telephone: "At the Newcastle office, to be sure. Who do you want to be put into communication with?" G.: "What de'ye mean? T.: "Who do you want to speak to?" G.: "Oh, that aad lass o' mine; she's at Newcassel." T.: "Who-llr-r-r-r lr-do-rrrllrr-you-llr'say? What is—l-l-r-r-r-l-l-r-r—the number?" G.: "What are ye gobblin' on that way for? Aa cannot myek oot what ye say. Aa want te speak to ma wife; she's at Newcassel. An' what d'ye mean be axin hor numbor—she's not a pollis, ye fyeul." Then there was a loud crash. The person at the Newcastle office had evidently hit the telephone a sharp rap, producing, of course, to the listener, sounds like an explosion. Geordy dropped the tubes and rushed down the stairs as fast as he could, nearly knocking over the office boy, who was just then returning. "What's the mettor?" shouted the boy, "What's the mettor?" returned the retreating Geordy; "dinamite! dinamite! thor's somethin' borsted!"—*Newcastle Chronicle.*

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THE DETERMINATION OF CURRENTS AND RESISTANCE IN A NETWORK OF CONDUCTORS.

(Continued from page 450.)

In following Dr. Fleming's paper we have so far been chiefly concerned with the development of a process of general application for the treatment of network problems. In the remaining portion of the paper this process is applied to the elucidation of some theorems of considerable theoretic interest, in which self and mutual induction in the branches of the network is taken into account.

We have, in the first instance, another proof, obtained in a very interesting manner, of a theorem due to Clerk Maxwell, and which he has put in the following terms :—"In any system of conductors in which there are no internal electromotive forces, the heat generated by currents distributed in accordance with Ohm's law is less than if the currents had been distributed in any other manner consistent with the actual conditions of supply and outflow of the current." When, however, the theorem has once been stated, it is readily perceived that this is but a special case of the results of general laws governing the transformation and degradation of energy.

We have next an investigation of the case of a shunted galvanometer placed in the circuit of a battery, taking into consideration the self-induction of the galvanometer coils. We will follow the steps of this solution somewhat in detail, as it is of a highly instructive character. We shall, however, give it in a somewhat simplified form.

Let G be the resistance of the galvanometer, L its coefficient of self-induction, S the resistance of the shunt, which, as is usual in practice, is supposed to be wound so as to have no self-induction; and let there be no mutual induction between the coils. Let E be the electromotive force of the battery and B its resistance.

Now, in dealing with problems which involve self or mutual induction, we must have recourse to the fundamental equation established by Maxwell for the treatment of the general case of electricity in motion. This equation yields an expression for the current at any given period of time in any circuit in which the kinetic energy, the impressed electromotive force, and the dissipation function are known—the "dissipation function" being an expression for the rate per second at which heat is being generated in the conductors throughout the circuit.

In the two-mesh network of the circuit under consideration, which is indicated in Fig 6, call the current in the galvano-

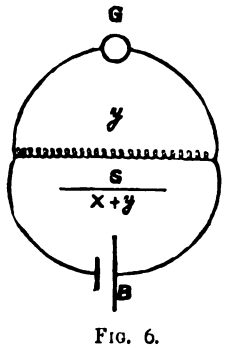

Fig. 6.

meter-and-shunt mesh y, and that in the shunt-and-battery mesh $\overline{x+y}$. Then the current through the galvanometer is y, the current through the shunt is x, and the current through the battery is $\overline{x+y}$. Now, in order to form the cycle equation for the mesh y, in which there is a branch having self-induction, we make use of Maxwell's general equation, which is as follows :—

$$\frac{d}{dt}\frac{dT}{dx} + \tfrac{1}{2}\frac{dH}{dx} = E.$$

Here H is the dissipation function, and is measured by the sum of the squares of the currents in each branch multiplied into the several resistances which they traverse. In this case we have

$$B\overline{x+y}^2 + Sx^2 + Gy^2 = H$$

which may be written

$$\overline{B+S}\,\overline{x+y}^2 + \overline{G+S}\,y^2 - 2S\,\overline{x+y}\,y = H.$$

Now, taking the first partial differential of this expression with respect to y, we obtain, for the second term in Maxwell's equation,

$$\tfrac{1}{2}\frac{dH}{dy} = \overline{G+S}\,y - S\,\overline{x+y}.$$

But this is seen at once to be the identical expression which would be equated to the effective electromotive force in the circuit, in forming the cycle equations according to the ordinary rule, if there were no self-induction in the circuit. It follows that, in order to obtain the complete expression for E, in accordance with the fundamental equation, we have merely to write down the ordinary cycle equation, and then add to it, upon the side opposite to the effective electromotive force, the value of the term

$$\frac{d}{dt}\frac{dT}{dy},$$

and this is a perfectly general rule.

Now, in the above expression T is the kinetic energy of the system, and in the case under consideration, treating as negligible the energy expended in moving the needle of the galvanometer, the kinetic energy of the system at any instant is wholly electro-magnetic, and will be measured by

$$\tfrac{1}{2}Ly^2 = T.$$

Hence $\frac{d}{dt}\frac{dT}{dy} = \frac{d}{dt}Ly$, and the complete equation for the y cycle will be given by

$$\frac{d}{dt}Ly + \overline{G+S}\,y - S\,\overline{x+y} = 0,$$

and for the x cycle we shall have

$$\overline{B+S}\,\overline{x+y} - Sy = E.$$

Rearranging, these become

$$\left(L\frac{d}{dt} + G\right)y - Sx = 0$$

and

$$By + \overline{B+S}\,x = E.$$

The solution of these, for x and y, is

$$y = \frac{\begin{vmatrix} E, & B+S \\ 0, & -S \end{vmatrix}}{\begin{vmatrix} B, & B+S \\ L\frac{d}{dt}+G, & -S \end{vmatrix}} = \text{current through [galvanometer,}$$

$$x = \frac{\begin{vmatrix} B, & E \\ L\frac{d}{dt}+G, & 0 \end{vmatrix}}{\begin{vmatrix} B, & B+S \\ L\frac{d}{dt}+G, & -S \end{vmatrix}} = \left\{\begin{array}{l}\text{current through}\\ \text{shunt.}\end{array}\right.$$

The first of these gives the following differential equation in y:—

$$\frac{dy}{dt} + \frac{BS+BG+SG}{(B+S)L}y = \frac{ES}{(B+S)L},$$

of which the solution is

$$y = \frac{ES}{BG+BS+GS}\left(1 - e^{-\frac{BG+BS+GS}{(B+S)L}t}\right).$$

Which result agrees with that of Helmholtz's equations for the current in circuits having self-induction at the end of any period, t, from the commencement of flow.

When stated in words this expression amounts to saying that after the lapse of t seconds the current in the galvanometer has a value which is less than it would have if there were no self-induction in its coils by a quantity the logarithm of whose reciprocal is inversely proportional to the coefficient of self-induction, and directly proportional to the total resist-

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ance of the circuit and to the time that has elapsed since the current commenced to flow. It will be seen that when t is zero, y is also zero, and as t increases y increases, but that it is not until t becomes equal to infinity that the factor within the brackets vanishes, and it is only then that y obtains the value given by the formula in ordinary use for the current through a shunted galvanometer.

If we write N for the factor within the brackets in the equation for y, we shall get for x, the current through the shunt,

$$x = \frac{E(BG + BS + BG - BSN)}{(B+S)(BG + BS + SG)},$$

and therefore the value of x diminishes as t increases. It will thus be seen that the self-induction of the galvanometer acts like a spurious resistance which is added to its coils at the moment the current commences, and which gradually dies away.

The combined resistance R of the galvanometer and shunt coils will thus be a function of the time t. From the cycle equations which are written above we may obtain R by means of the method previously considered. We shall have to take the battery-circuit resistance equal to zero, that is put $B = 0$; then, writing down the determinant of the cycle equation, and dividing by its first minor, we have

$$R = -\frac{\begin{vmatrix} S, & -S \\ -S, & G+S+L\frac{d}{dt} \end{vmatrix}}{G+S+L\frac{d}{dt}} = \frac{S\left(G+L\frac{d}{dt}\right)}{S+\left(G+L\frac{d}{dt}\right)}$$

And it may be shown that the expression $\left(G + L\frac{d}{dt}\right)$ is equivalent to

$$\frac{G}{\left(1-e^{-\frac{G}{L}t}\right)},$$

and therefore,

$$R = \frac{SG}{G+S\left(1-e^{-\frac{G}{L}t}\right)}.$$

We have next an examination of the case when a condenser discharge is taken through a shunted galvanometer. This investigation, which is of a more difficult character, is very ably treated by Dr. Fleming. He arrives at the somewhat remarkable result that the *total* quantity of the discharge is divided between the two circuits merely in the inverse ratio of their resistances. So that self-induction does not affect the the ratio of division of a discharge in a divided circuit; provided, however, that no external work is done such as the moving of magnets, or of circuits conveying currents. Hence, if a ballistic galvanometer is shunted and a discharge sent through it, even in the case when the shunt has self-induction, so long as the needle has sufficient moment of inertia and the discharge is sufficiently short, so that the needle has not perceptibly moved from its position before the discharge is over, then the whole quantity of electricity is divided between the galvanometer and the shunt in the inverse ratio of their resistances. The examination of the value of the current flowing through the galvanometer and shunt at any instant leads to the result that, if the self-induction of the galvanometer exceed a certain limit the discharge from the condenser may assume an oscillatory character. For the case in which the shunt has no self-induction, in order to prevent this electrical oscillation in the galvanometer circuit, we must have the relation

$$\frac{G^2 S}{G+S} > \frac{4L_1}{C}$$

where L_1 is the coefficient of self-induction of the galvanometer, and C is the capacity of the condenser.

If the original quantity in the condenser be Q, and if y be the value of the current in the galvanometer circuit at any instant, then after the commencement of discharge it may be shown that for y we shall have

$$y = \frac{Q}{\sqrt{\frac{G+S}{S}CL_1 - \frac{G^2C^2}{4}}} e^{-\frac{G}{2L}t} \sin\left(\sqrt{\frac{G+S}{SL_1C} - \frac{G^2}{4L_1^2}}\right)t.$$

The memoir concludes with two examples which are taken from the course of lectures upon electromagnetism which Prof. Clark Maxwell delivered at Cambridge in the May term, 1879, an occasion which, unhappily, proved to be the last on which Maxwell was able to discharge his professorial duties.

The first of these theorems is on the comparison of the mutual induction between any two pairs of coils. Let α, β, γ, δ be four coils of wire. It is required to compare the mutual induction of α and γ with that of β and δ. The coils are placed in position and joined up as shown in Fig. 7, α and β in series with a galvanometer, γ and δ in multiple arc with a battery.

Let R and S be the resistances of the primaries γ and δ, and let Q be the sum of the resistances of the two secondaries and of the galvanometer, and let the resistance of the battery be

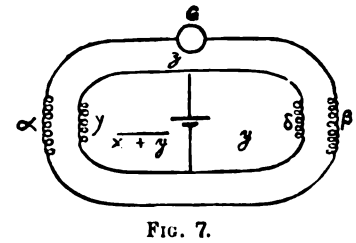

FIG. 7.

neglected. Let the coefficients of self and mutual induction be taken as follows:—

Coefficient of self-induction of coil	α	$= L_1$
" " "	β	$= L_2$
" " "	γ	$= N_1$
" " "	δ	$= N_2$
" " galvanometer		$= \Gamma$
" mutual induction of coils	α and γ	$= M_1$
" " "	δ and β	$= M_2$

Call $\overline{x+y}$ the cycle current of the mesh containing γ, y that of δ, and z that of the secondary circuit. Therefore, the current through the battery will be x. The kinetic energy of the system is given by

$$2T = \overline{x+y}^2 N_1 + 2\overline{x+y}\,z M_1 + z^2(L_1 + L_2 + \Gamma) + y^2 N_2 + 2yz M_2.$$

Hence, writing the cycle equations as before, and adding to each the respective value of

$$\frac{d}{dt}\frac{dT}{dx}$$

obtained from this expression, we shall have

$$\begin{aligned} n\overline{x+y}N_1 + nzM_1 + \overline{x+y}R &= E \\ nyN_2 + nzM_1 + yS &= -E \\ n\overline{x+y}M_1 + nyM_2 + nz(L_1+L_2+\Gamma) + zQ &= 0; \end{aligned}$$

where for convenience n is put for $\frac{d}{dt}$.

From these equations, eliminating y, we may obtain z in the form

$$z = \frac{\{n^2(M_2N_1 - M_1N_2) - n(M_1S - M_2R)\}x}{\text{a denominator which does not concern us}}.$$

If matters are arranged so that $z = 0$, or the galvanometer shows no current,

$$(M_2N_1 - M_1N_2)\frac{dx}{dt} = M_1S - M_2R.$$

Hence if there is no "kick" on the galvanometer on making current, then

$$\frac{M_1}{M_2} = \frac{R}{S}.$$

(To be continued.)

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UNDER THE HAMMER.

The quaint conceits of Lamb, or the versatility of Goldsmith, would have endowed the auctioneer's hammer with a charm which modern writers fail to give. The delicate touches of humour which hovered, as it were, around the subject never failed to soothe the reader, and to bring his mind into accord with that of the writer; although it may be that in some cases their natural flow of language and fertility of idea led these authors to clothe their inceptions in a garb of such superabundant beauty that the moral they sought to inculcate was lost in the telling. The moral of the auctioneer's hammer is, however, always plain. It shows the volume is closed—with "failure" written distinctly across the last page. There can be no mistake; the result is clear.

Good may, however, come from failure. Others may be led to inquire into the causes which led to that failure, and, taking care to avoid those causes, to work steadily onward and upward to success. It is to be hoped that this result will accrue to those engaged in electric lighting. The Hammond Company, one of the largest companies floated for electric light work, has passed away. The auctioneer has, during this and the preceding week, been busy disposing of the effects of the company. The lesson to be learnt has been taught in a rough and violent manner, though it is none the less valuable. The large companies floated in the halcyon days of hope were undoubtedly a mistake. The sums of money paid for patents and concessions were far too great, and have proved millstones around the necks of drowning men. There is not a single electric light patent that gives its holder or holders a monopoly. Dynamo machines are made on every hand, and the machines of different makers are so admirably constructed as to make it very difficult to decide which is the best. Good arc lamps are to be obtained from various firms, and at least half a dozen makers of incandescent lamps have their wares before the public. When the history of artificial illumination comes to be written, the chapters devoted to the initial development of electric lighting will have to deal with numerous mistakes. It is easy to point out these mistakes after they have been made. The difficulty is to show that a certain course of action will be a mistake before such action has been commenced. The perils and dangers of the system pursued as regards electric lighting were pointed out in the initial stages of the industry, but the alarmist view was poohpoohed as being simply the opinion of a very small minority. Experience has since shown those views to have been correct; though such experience comes too late to save investors from the effects of the system adopted. Illumination by gas did not supersede illumination by oil in a year; nor did the network of railways thread the whole country within a similar period. An attempt to run before being able to walk generally ends in disaster, and the course of electric lighting has been no exception to the rule.

It is pleasant to find that the public is beginning to value concessions similar to those imported into electric light speculation at a proper estimate—that is, as having no value whatever. They increase the cost of plant, and are favourable to untrammelled competition, without having any corresponding advantage. The only favourable opinion about these concessions is to be obtained upon the Stock Exchange. A fictitious value is therein given to them in order to induce speculation. The fatal error made by those who promoted the system of concession was to conclude that the special machinery made under the patents they controlled was machinery that could not be approached, much more surpassed in excellence, by any other maker.

We cannot say how it is, because we have not been behind the scenes so far as the company is concerned whose break up gives us our text, but we should imagine that the untoward result is traceable to three causes. In the first place we have the amounts paid for concessions and patents; then we get the apathy of the public to support by its patronage so large a capital; and, lastly, we have the errors of forecasting the cost of work, so that the doing of the work ends in loss instead of gain. The causes, it seems to us, are common to the development of new industries. Ultimate success is generally built upon failure. It is a common saying that those who bear the burden and heat of the day do not reap the reward. The same reasoning that applies to the purchasing instead of the building of a house applies to a new industry. Those who rush to encounter and to overcome early difficulties are generally ruined; those who wait can take advantage of the experience gained and are successful. These facts are not to be gainsayed, though they have been overlooked. Time brings about its revenge, and the history of the electric light will be found to be nothing out of the common.

A few words may not be amiss as to the apathy of the public. This apathy is comparative, and only exists in the imagination of the promoters of companies. Thousands of men would like to have the electric light in their houses, but they have to consider that already a large outlay has been incurred, and that, however cheap and good the new illuminant may be, its introduction will necessitate a considerable initial expense. After all, it is useless to contend or to attempt to persuade a man that he ought to spend two or three hundred pounds at once when he has not got the money. An extra five or ten pounds a year is easily met and paid; when the first

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THE INTERNATIONAL INVENTIONS EXHIBITION.

In the East Court Messrs. J. D. F. Andrews and Co. exhibit a selection of apparatus illustrating the details of their electric light manufactures.

As a starting point in his work Mr. Andrews decided that, for a system to be general, the complications involved in arranging fittings for two wires would be out of the question, and he therefore worked out the various appurtenances of his complete system for the one wire principle, whether applied to ships or buildings.

He has arranged all fittings to be entirely independent of the wires that lead the current to them, so that they may be removed from their place of erection without in any way interfering with the wiring, and the various parts of the fittings may be taken to pieces without each part carrying its own connections. Several kinds of these fittings are exhibited, consisting of double-jointed brackets with switch in the fitting and safety fuse in the backblock, electroliers, ship fittings of all kinds, switches with quick break without springs, suitable for sinking in the wall or the floor, as a gas tap now is, and safety fuses to suit, and switches of the same mechanical design arranged to fix on the face of the wall, &c.

There are also a variety of fittings on exhibition for the double wire system for cases of special necessity, besides arc lamps and dynamos.

Mr. Andrew's dynamo is a four-pole Gramme machine

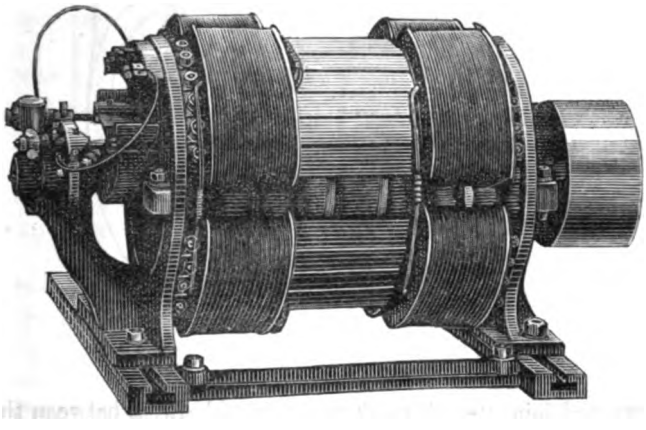

FIG. 1.—Andrews' Dynamo.

arranged in a novel way, as will be seen in Fig. 1. The armature (Fig. 2) rotates within a cylinder, nearly three times

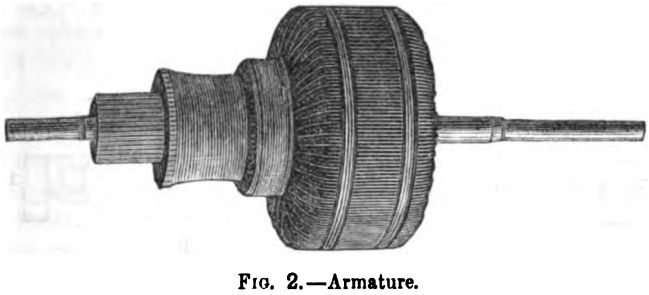

FIG. 2.—Armature.

as long as itself, and formed of wrought-iron bars, arranged like the staves of a cylindrical cask. The cylinder, or cask, to keep to our simile, is not entire all round, some of the staves being omitted so as to create four longitudinal openings ninety degrees apart. These staves form the field magnets, the central portion being the poles, the bobbins being arranged at each end of each group. There are no pole pieces, and consequently there is no break in the magnetic field except at the neutral points, where the framing acts as coupling between the adjacent magnets.

A special feature of the machine is the method of connecting up the coils of the armature to the commutator, which we show in Fig. 3. N N and S S represent the staves forming the poles, and C C C the armature with its coils, and M the commutator. It is necessary, according to this method of connecting, that the number of coils should be uneven. Usually 59 are employed, but only 17 are shown.

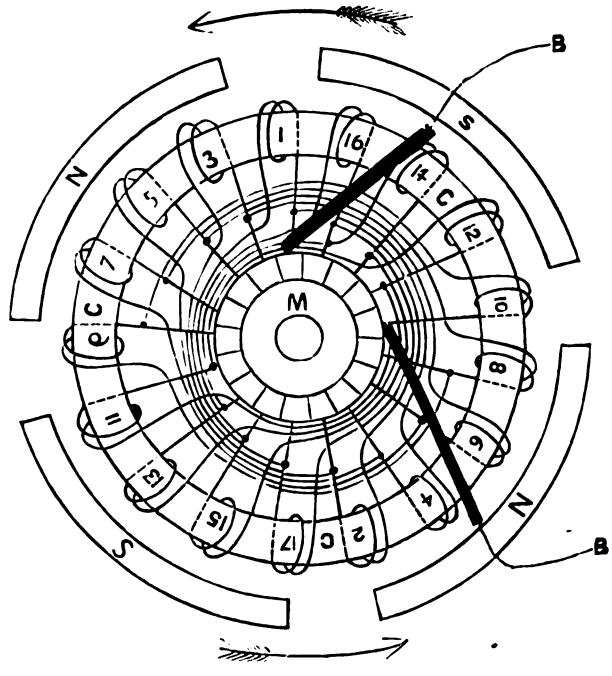

FIG. 3.

The coils are connected in series; not, however, each one to its next-door neighbour, but each to its diametrically opposite neighbours—that is, coil No. 1 is joined between Nos. 17 and 2, and No. 2 between Nos. 1 and 3, and so on. One end of each coil, however, is connected to the commutator plate nearest to it, as will be better seen on the diagram than described.

The collection of the currents from these coils is effected by placing two brushes, B and B, at right angles to each other on the commutator; thus, as coil No. 1 enters field N its other half, or coil No. 2, which is connected to it, enters field N and brush B collects the current. Correspondingly, as coil No. 10 enters field S and its other half No. 11 field S, the brush B is in position to gather the current from both south poles. The adjustment of the brushes on the commutator is another new feature of the dynamos. On an axle (Fig. 4) are held two

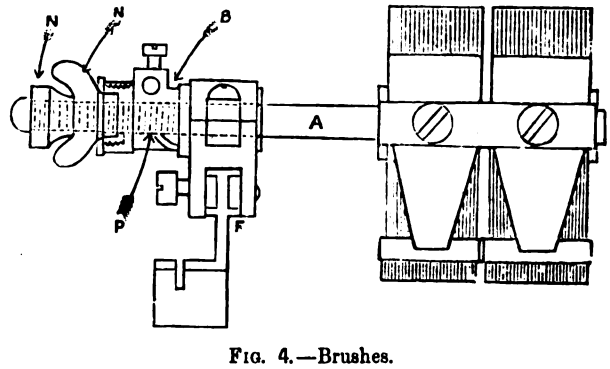

FIG. 4.—Brushes.

brushes in one holder. This axle passes through an insulated brass sleeve or bearing B, and its screwed end fits into the thumb nut and lock nut N N; the thumb nut is turned, the brush axle is drawn through the sleeve, and a pin, P, fixed to the axle, and fitting into a spiral slot in the sleeve causes the axle to turn and press the brushes on to the commutator or lift

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them entirely off. With this simple arrangement the pressure can be very finely adjusted.

Fig. 5. is an end view, showing the two brush holders fixed to a semi-circular brass frame, F, upon which they can be shifted independently and the angle adjusted, and after this the frame itself carrying both brushes may be oscillated till the point of no sparking and best effect is found on the commutator.

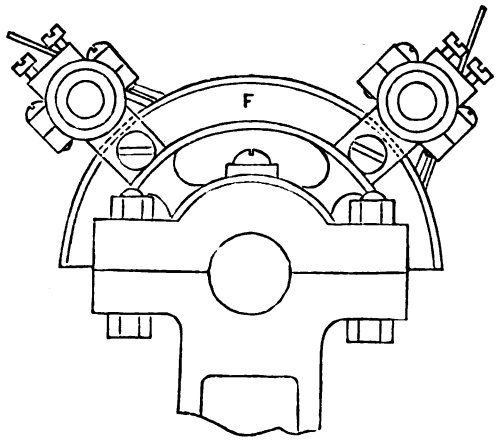

FIG. 5.—End View of Brush Holders.

One of these machines, size B4, is supplying current to 8 25-ampere arc lamps lighting the engine shed. The lamps are connected up in four branch circuits parallel, two lamps and a resistance of six ohms being on each circuit.

Arc lamps are also exhibited on the stand. Those lighting the engine shed are of the simplest type for running in parallel circuits. They regulate with great certainty and steadiness, and consist of a long solenoid of fine wire, connected as a shunt to the arc, in which hangs a core suspended by a ribbon passing over a pulley, which can rotate in one direction only to lift the core. When the core descends, the ribbon slides over the pulley, and acts as a brake, the other end of the ribbon carries a tube to which the upper carbon is attached. This tube is within another that acts as a guide, and a slot is cut through its whole length to allow of a flexible connection being attached to the carbon holder tube. The core carries the bottom or negative carbon, and being heavier than the positive holder, the carbons are apart so long as there is no current passing through the solenoid. The moment the current starts the solenoid has great power, till it lifts the lower carbon against the upper one, and thus short circuits itself, and allows the carbons to part and so form an arc. The strength of the current now passing through the solenoid depends on the difference of potential of the two carbons, and so long as the difference of potential remains constant, no matter what variations take place in the quantity of current through the carbons, the solenoid will regulate the arc to the required light; consequently, the lamp being once adjusted to a fixed electromotive force, the light may be varied from 500 candle-power to 3,000 by increasing the current without any further adjustment.

The solenoid has a greater power over the core, as the latter enters, than when it is within, to its full length; and as it is necessary this power should be uniform to keep a uniform length of arc as the carbons are consumed, a very simple device of a heavy chain, H, passing over a pulley is arranged, as will be better seen in Fig. 6. One end of the chain is attached to the upper end of the positive carbon holder tube, and passing over the pulley; the other end is attached to a lead weight or number of weights, W, which are made removable, so as to regulate the lamp. Thus, when the core is at its lowest in the strongest part of the solenoid, the chain is balancing part of the weight of the positive carbon holder tube, which is itself a counterbalance to the core, and as the core ascends the distribution of the weight of the chain is gradually reversed till the whole weight of the carbon holder tube is balancing part of the core.

This lamp is arranged to work in series by the addition of an automatic shunt, A, placed in the upper portion of the lamp. This will be better understood from the diagram Fig. 7 and plan Fig. 8.

In addition to the shunt it is necessary to wind a thick wire solenoid, B, forming part of the circuit or main wire, over the working fine wire coil. One end of this is connected to the terminal and the other to a contact, D, on which the spring E

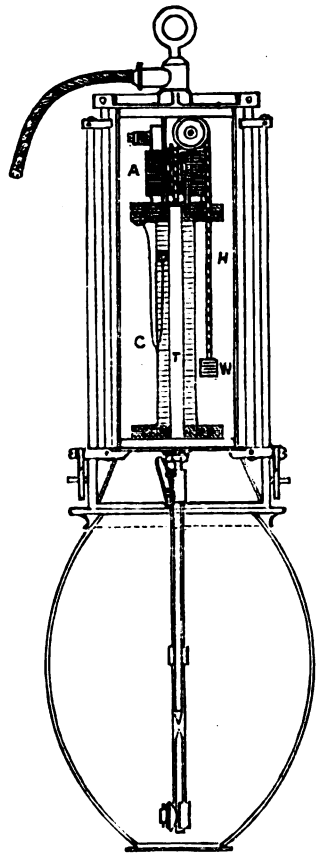

FIG. 6.

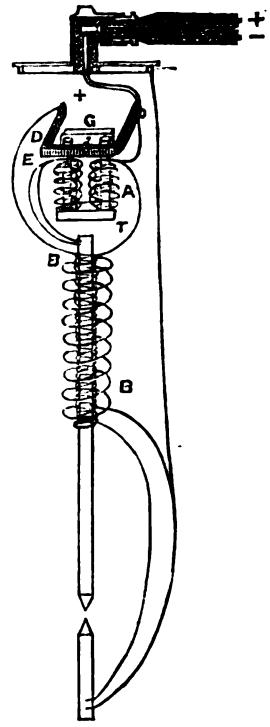

FIG. 7.

rests, and joins up this thick wire solenoid direct between the terminals of the lamp. Supposing now the current to be started its power in the solenoid will bring the carbons into close contact, and the current will now also pass through the thick wire on the magnet F, through the carbons and away. This magnet,

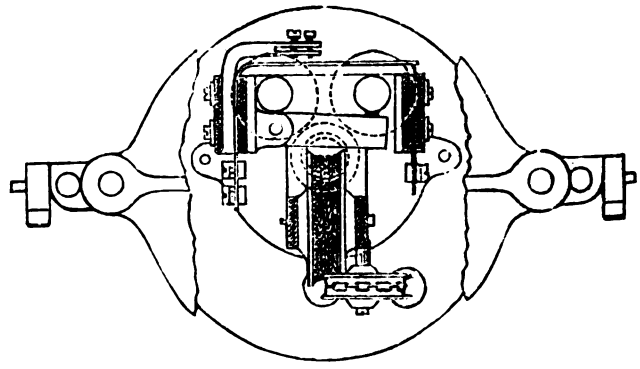

FIG 8.

by means of the armature G, will break the circuit of the thick wire solenoid at D, and allow the carbons to part and form the arc. The lamp now goes on regulating with the fine wire solenoid, the thick wire solenoid being cut out. If the arc should grow extra long or stick through dirt, the magnet F, which is wound also with fine wire, opposing the current through the outer solenoid, forcibly adjusts the carbons.

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Another arrangement of this lamp is shown in Fig. 9. It is well adapted to burning parallel, and is specially designed to stand rough usage; the lower carbon holder is fixed, and the solenoid is part of the circuit wire. As in the other lamp, the chain compensation is necessary, and the ribbon carrying the coil, after passing over the pulley from the core, is attached to a counter weight, and to this also is attached the chain passing over the sheave, and carrying a smaller weight at the other end.

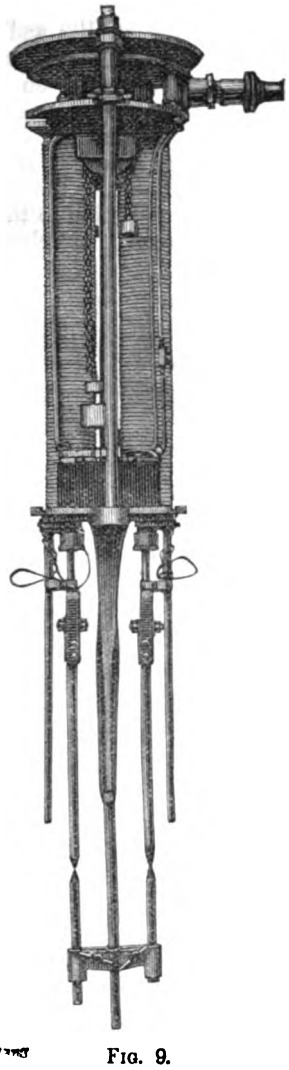

FIG. 9.

Now, let us suppose the lamp to be ready to be lighted. The carbons will be in contact, the greater part of this weight being carried by the ribbon when the circuit is completed; the solenoid will lift its core and establish the arc, and the combined influence of the solenoid, the friction of the ribbon, and the counter weight will hold the parts in position. As the arc lengthens the solenoid will gradually lose its power, and its core will slide down to compensate for the waste. This lamp is always made in duplicate in the one frame, with an automatic shunt to switch in the second, when the first is finished burning, or when the first is being trimmed with fresh carbon.

The armature core is a coil of No. 12 iron wire, measuring 17½in. diameter, 8in. wide by 1⅝in. thick; on this core are wound 185 yards of cable, consisting of 14 strand 16 B.W.G., in two layers and 59 sections. The outside of the core is set at seven-eighths distance from the inside of the magnet poles, and when it rotates at a speed of 2,300ft. per minute an electromotive force of 110 volts, and a current 110 amperes are generated in the cable wound on it, being 1 volt to each 1·85 yard of wire, which, taking the lowness of speed into account, is a very good result.

At Messrs. Paterson and Cooper's stand, in the East Arcade, are exhibited several of their latest types of Phœnix dynamo machines for arc and incandescent lighting and for electro-

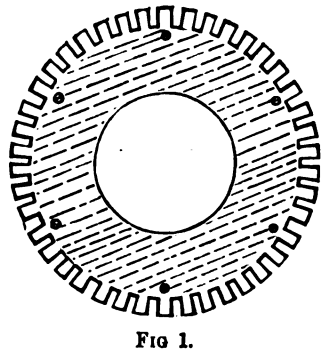

FIG 1.

plating. These machines are made some with wrought iron field magnets and some with cast iron magnets, and are of several different types, according to the purpose for which they are designed. The armature of the machine is constructed of plates of wrought iron of the softest quality, punched out and melted to the shape shown on the diagram (Fig. 1), the wires being wound in the slots, two coils in each. The plates are carefully insulated from each other by sheets of paper, and the whole armature firmly braced together by insulated bolts passing through the armature from end to end. In construction the object has been to obtain a substantial and strong mechanical connection between the armature and the spindle consistent with completely insulating every part where an absence of this precaution would tend to the generation of wasteful Foucault currents, and Messrs. Paterson and Cooper claim to have in the Phœnix machines succeeded in gaining their object. The machines are of strong substantial design, and all built to do heavy work, and with due regard to durability.

In Fig. 2 is illustrated a longitudinal section of the 1,000-light Phœnix machine running nightly in the electric light shed. The magnets of this machine are of wrought iron bars, 9in. square, arched in the centre, and having cast iron yokes at each end which serve as the base of the machine. From these yokes, on each side of the armature, springs a cast iron spandril, which supports, in gunmetal bearings, an armature spindle. This is clearly shown on Fig. 3. The armature is constructed, as above described, of wrought iron plates, and has wound on it 84 coils having a similar number of sections in the collector. The collector has a wearing depth of three inches, and the machine is fitted with double brushes, which are not only capable of adjustment round the collector, but which can be altered in position relatively to each other by adjusting screws actuating sliding blocks. The armature is wound with a conductor formed of 50 small wires laid together and covered with four thicknesses of varnished tapes. Such a conductor is much more easily wound than a conductor formed of a few thick wires in parallel, and it is more suitable for armatures of this form than are simple bars of copper. It appears that in this machine the proportion of copper wire to iron has been reduced to a minimum. Another machine, for 200 lights, of different design, also running in the electric light shed, is also exhibited. The magnet bars in this machine are of square form, as before, but pole-pieces of cast iron are employed. These two dynamos, in conjunction with a smaller machine, light the dining halls and the buffet by Bernstein lamps of 50 candle-power each, the lamps being suspended from the roof in groups of threes, enclosed in effective conical glass shades. In addition to the several different sizes of dynamos, varying from 10 to 200 lights, made by this firm, and employed at different parts of the Exhibition, there are two 12-light arc machines running in the electric light shed to supply current for 24 Phœnix arc lamps employed to light the west burners. The opal glass lanterns which enclose these lamps are of a new design, and look very well. The lamp is of the clutch type, and the feed is effected by a vibrating hammer, which continuously delivers infinitesimally small blows on the free side of the clutch, the hammer being actuated by a differentially wound shunt magnet. At Messrs. Paterson and Cooper's stand are shown, besides the Phœnix lamp above described, the Clark-Bowman, the Pilsen, and J. F. arc lamps, for all of which the firm are agents. The selection of measuring instruments shown here is very complete. Some Wheatstone bridges, resistance boxes, and reflecting galvanometers of first-class workmanship are exhibited, as well as the ordinary line testing instruments employed by workmen. A good assortment of Ayrton and Perry's ammeters and voltmeters is shown; but these instruments are so well known as to call for no special description here. It might just be mentioned *en passant* that all instruments now made by this firm are calibrated direct in amperes and volts, and that the deflections are always proportional to the current flowing. Paterson's electro-magnet ammeter is an instrument which may probably be new to some. In this instrument the permanent magnet is replaced by an electro-magnet which is magnetised by the current which deflects the needles. The voltmeter invented by Capt. Cardew, now that some hundred are in use, can scarcely be considered a novelty, but its action may be here briefly described. The voltmeter consists essentially of a fine platinum silver wire, one end of which is attached rigidly to one of the terminals of the instrument, and the other to a staff or pulley which by its rotation indi-

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cates the amount of expansion the platinum wire has undergone due to the passage of the current through it. A certain difference of potential at the terminals of the wire gives a certain expansion, and a needle fixed on the staff indicates the difference of potential on a dial calibrated direct in volts. These instruments can be kept on the circuit continuously, as the heating by which in galvanometric voltmeters the efficiency of the instrument is impaired is here employed to produce the indications. Having no coiled wires, the error introduced due to self-induction is not found in these instruments, and they can consequently be employed for alternating as well as continuous currents. A fuse of very fine wire is placed in the instrument to prevent fusion of the working wire, should the difference of potential at the terminals of the instrument exceed the working limit. Several of Paterson's engine room ammeters are shown, and also Paterson-Joel ammeters.

One form of Thompson and Starling's patent universal photometer for measuring the candle-power of incandescent or arc lamps consists of a graduated bar, at the centre of which are fixed back to back two opaque screens attached to one another at a small angle. On one screen falls the light which is to be measured ; on the other falls the light from two standard candles of spermaceti.

By adjusting the relative positions of the candles and of the light whose intensity is to be measured the relative intensities are ascertained, and the scale marked on the bar of the photometer is so graduated as to reduce the calculations to a minimum. When the instrument is employed to measure the candle-power of arc lamps it is set on a tripod, and a mirror is employed to throw the light from the lamp directly on to the screen. In addition to these exhibits the firm have several specimens of their electro-

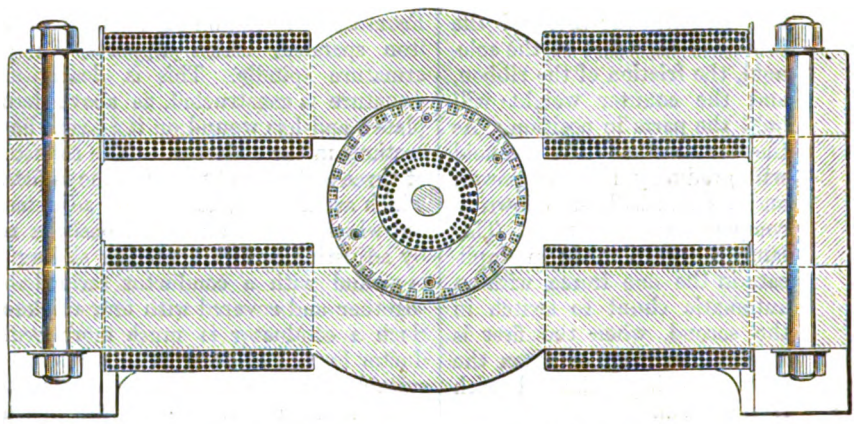
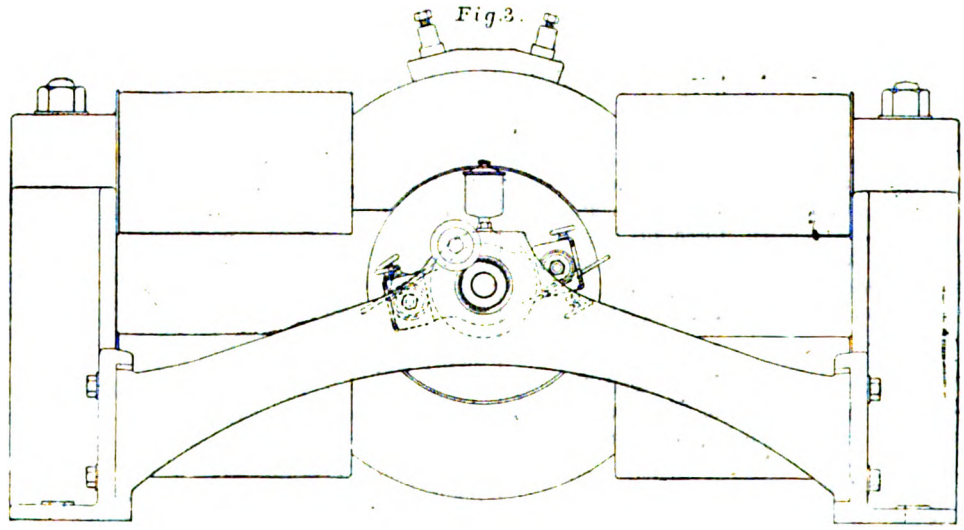


FIG 2.—Phœnix Dynamo. Longitudinal Section.



Phœnix Dynamo.

In these instruments the galvanometric coil is replaced by a single strip of copper. A number of ornamental fittings and shades for incandesceut lamps are exhibited along with all the necessary apparatus and accessories required for fitting up installations such as the well-known Eidesforth and Co. and Maynard switches, fuses, fuse holders, lamp holders, &c. A selection of Wallace, Diamond, and other carbons employed for arc lamps can also be seen. A battery of 20 Joel accumulators is shown, and in this accumulator it is claimed that the principal difficulties which have been incidental to the use of accumulators in the past have been overcome. The positive and negative electrodes are firmly braced together in a wooden frame, and are quite independent of the cell or box in which the dilute acid is contained. They can therefore be lifted out and inspected at any time.

deposition of metals, including zinc, brass, copper and tin deposited on iron ; nickel on iron, brass, and copper ; silver on iron, copper, and brass, &c. A small dynamo used for electroplating is shown, which is capable of depositing 5lbs. of nickel per day.

Side by side with this is a machine for copper refining, which is capable of refining 5 cwts. per day. Machines are constructed by the firm capable of depositing one ton of copper per day. Photographs of most of the machines made by the firm are exhibited, which vary in size from machines for ten 20 candle-power lamps to machines for one thousand 20 candle-power lamps. Many of the machines have been made for special purposes, and several are working continuously with the greatest success in different parts of the world.

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outlay is absolutely unattainable. The earlier exponents of electric lighting acted as if men individually or collectively would wish to pay the initial charge, and gladly write off as lost the amounts already paid for other illuminants. Nothing of the kind has happened. The electric light has been introduced into factories where the proprietors thought directly or indirectly it would pay them to do so. Individuals who can afford luxuries have introduced the light; and in this manner its use is extending, and will as time goes on more rapidly extend. These, and a host of other thoughts rush through the mind as we contemplate the fall of the auctioneer's hammer. Our sympathy goes out to the sufferers, though we cannot wholly refrain from pointing out that no other solution than that which has occurred was possible. A certain, but comparatively small, capital is all that the electric lighting industry will at present support. There was too much capital, and natural laws have acted in its extinction. We trust that in the near future natural laws will act to bring about a different result.

CORRESPONDENCE.

ON LOW RESISTANCE INCANDESCENT LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The interesting Cantor lecture of Prof. Forbes which you published in last week's *Electrician* induces me to make a few remarks upon low resistance incandescent lamps, in connection with which Prof. Forbes mentioned my name.

Let me first consider the lamp itself, irrespective of its application for the purpose of distributing electric light.

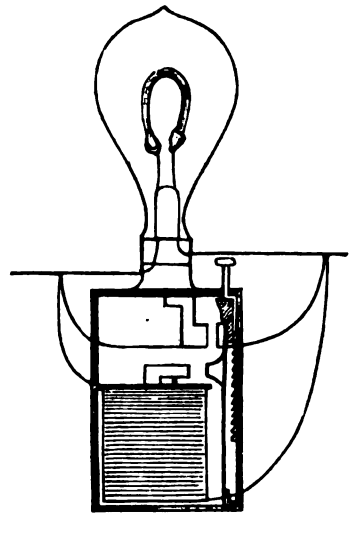
I cannot understand why lamps of low resistance should *à priori* be considered less economical in the production of light than those of high resistance. To my great surprise, I have occasionally heard the expression that high E.M.F. in incandescent lamps favours the generation of light; and I am inclined to think that a faint notion of possible relations between electricity and light is at the bottom of such vague ideas. Now, E.M.F. in itself is merely a tendency to do work, but the actual work is done by the current, which generates the heat in the carbon; and again, it is the temperature of the carbon on which the amount of light radiations depends. Different substances will emit different amounts of visible radiations if heated to the same degree of temperature. I am inclined to think that our knowledge on this very important point for the production of artificial light is more deficient than it ought to be. But in the absence of proofs to the contrary, we may assume that the amount of light radiations emitted by incandescent carbons of the same quality and surface is merely a function of its temperature. Now, it can make no difference whether the heat-generating current is produced by a low E.M.F. working through a low resistance or a high E.M.F. working through a high resistance.

As to the amount of heat which is lost at the terminals, the same is alike in both kinds of lamps, if the dimensions of these terminals are in proportion to the amount of current which is passing.

In order to still more convince Prof. Forbes, whose good opinion on low resistance lamps I should like to win, I may be allowed to mention that, according to the measurements made at the Vienna Exhibition, the Bernstein lamp of low resistance has shown the highest degree of efficiency; and, furthermore, I should like to call attention to the interesting experiments on the relation between light and heat radiations in different incandescent lamps made by Mr. Penkert in Hanover, and published in the *Centralblatt für Elektrotechnik*, No. 22, 1885. Furthermore, it can certainly not be denied that a lamp with a short tube of large diameter is far more agreeable to the eye than one with a very long thin filament.

I now come to the application of low resistance lamps for the practical purposes of lighting. Four years ago I devoted considerable time to the production of large candle-power incandescent lamps, which were intended to take a place between the ordinary arc lamp and the small incandescent lamp then gradually coming into use. It seemed to me that it ought to be laid down as a general principle for economic electric lighting that the size of light to be used should be in proportion to the space to be lighted, and should be as large as the proper distribution of light will allow. It appears a mistake to light large areas, like railway stations, with small incandescent lamps. Now, as the arc lamp has never proved very satisfactory, my desire was at the same time to replace it by suitable incandescent lamps, and I shall quote an example of such replacement later on. For reasons, the explanation of which would lead too far from the subject, I came to the conclusion that a hollow carbon would have those qualities which I considered most desirable in a practical lamp of large candle-power, and after long and tedious experiments in this matter I met with some success. It further occurred to me that it would often be advantageous to place incandescent lamps in series, as the multiple arc system offers many difficulties, which Prof. Forbes has so ably described in his lecture.

The lamp for this purpose had then to be of low E.M.F. and large current. As a matter of course, it was necessary to use a device, in order to prevent the interruption of the circuit, in case a lamp should break accidentally; but this is by no means so difficult as Prof. Forbes seems to imagine. It does neither require a local battery nor a separate wire from the dynamo. As the simple arrangement which has been used in several places in connection with the Bernstein lamp for the last two years has never been described in any electrical paper, although the same was shown in Vienna and in Philadelphia, I may embrace this opportunity of giving a sketch of it.



A small box, which generally serves as a lamp holder at the same time, contains an electro-magnet, which is placed in a shunt round the lamp, and therefore wound so as to represent about a hundred times the resistance of the lamp. If this magnet attracts its armature, which is fastened on a flexible brass strip, contact is made between two pieces above the armature, so as to close a short circuit around the lamp. In order to insure a good contact a wedge is arranged in such a way that it rests on the brass strip, as long as the same is not attracted towards the magnet, but slides down behind the brass plate as soon as this begins to move, and in this position it presses the two contact pieces together. After the broken lamp has been replaced by a new one the wedge is lifted by hand into its former position, when the current will again pass through the lamp.

The action of these cut-outs depends upon the peculiar behaviour of incandescent lamps when several of them are placed in series. In this case the lamp does not give out suddenly but gradually, because an arc is formed and long sustained

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between the two ends of the broken carbon. The resistance of the lamp then increases many times, and therefore the current in the shunt electro-magnet becomes soon strong enough to act. In fact, I have never known any of these cut-outs to fail.

If two lamps are used in parallel, then the electro-magnet is wound differentially with the line wire, and one cut-out will answer for both lamps. This later arrangement was adopted two years ago in an installation about which I should like to say a few words.

In the Nantasket Hotel, near Boston, Mass., 16 arc lamps had been used for lighting the dining rooms, passages, verandahs, &c., but, on account of the unsteadiness and flickering of the arc lamps, the lighting was not considered satisfactory. I therefore made the following change :—I replaced every one of the arc lamps by four incandescent lamps, each having half the current and half the E.M.F. of the arc lamps. Although the total amount of light produced was of course less than before, this difference did not appear so very large, as the arc lamps could not be used without opal globes. There was a reduction of expense, and the effect was considered far more pleasing than before. To my knowledge the new arrangement has given great satisfaction up to the present time. I mention this case because I believe that the example may be considered worthy of imitation.

Prof. Forbes will be interested to know that the idea of regulating the light of incandescent lamps, when placed in series, by altering the length of the light-giving carbon, is embodied in my English patent No. 6,075, 1885.

I must forbear enlarging further upon this subject, although a great deal may be said on the use of low resistance lamps, especially for street lighting. But, in order not to be misunderstood, I wish to state that I by no means recommend the use of low resistance lamps for all purposes. At the present stage of electric light engineering they are entirely out of the question where large numbers of lamps are to be arranged quite independent of each other.

The special feature of the Bernstein lamp is not the low resistance, as has often been stated by mistake in electric literature ; but it is the use of the tubular carbon, which can be made for small and for large currents, with this distinction, that where large lights are required the hollow carbon alone will answer, as far as my experience goes. But I have of late made 100-volt lamps, which only require ·35 ampere, and represent a cold resistance of 570 ohms. In fact I am at present engaged in experimenting on two kinds of lamps, which may be taken as the extremes—one for the largest possible current, to be used for lighthouse purposes and projectors, and the other with the thinnest practicable tubular filament and the use of high E.M.F. for the distribution of electric light from central stations.

Between these two extremes there are a great many intermediate lamps which will be found useful for practical purposes.

I hope that the great interest which is attached to the subject of this letter will serve as an excuse for the great length of it.—Yours, &c., ALEXANDER BERNSTEIN.

A PHENOMENON OF CURRENT INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have carefully studied the reply of Mr. Sprague to my further inquiry on this subject, and feel again indebted to him for devoting so much attention to a matter that has perhaps engrossed my own interest more than that of others. I was using a very vague expression when I suggested that "completing the secondary circuit *relieved* the primary coil," and therefore have myself to thank if it has been misunderstood. However, I meant that the primary coil was relieved, not of extra current to be carried, after break, but of an *external load* on the primary current itself—that is to say, of a certain counter E.M.F. coming from the secondary wire. Thus I am unfortunately unable to feel Mr. Sprague's interpretation confirms my own. Moreover, I betrayed (p. 396) that I believe in a stronger primary current when the secondary line is closed as lying at the root of the matter, so that we are not yet altogether in agreement.

I now understand clearly that Mr. Sprague supposes that the prolongation of magnetism in the core after break will be *less* when the secondary is completed than when it is open. Such a view, however, brings me face to face with a strange anomaly, for I reason that the secondary circuit when incomplete is practically *not* a circuit, and might as well not have been wound on ; so that the two cases under consideration are :—(*a*) Primary wire alone upon core, (*b*) primary wire upon core, with additional fine-wire circuit (closed) wound outside ; and in case (*b*) the prolongation of magnetism is to be less. But it is for me a hard saying when I am told that winding on additional wire as a circuit for the core to act upon, be it thick or thin, can have any other effect than that of increased prolongation of magnetism owing to its reaction. I also find some contradiction in supposing that the increased facilities of the metalically closed secondary should be favoured with "nearly the whole current," unless this circuit offers less resistance than the primary ; but, in that case, why should the energy appear there as "E.M.F. rather than C ?"—Yours, &c., E ALDRED WILLIAMS.

26th October, 1885.

SHIP LIGHTING AND COMPASSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with interest your note in issue of 16th October on Commander Hudson's article in the *Nautical Magazine*.

To my mind, the fact that so many of our steamers are running fitted with electric lamps, without any complaints of misbehaviour of compasses being heard, is sufficient of itself to refute Commander Hudson's theory.

With regard to the intrinsic merits of the two systems—single and double—of wiring iron ships, I have had considerable experience in both systems, and am of opinion that the design and workmanship being equal in both cases, the single wire system is the better and safer of the two. I should always use it when free to do so. One of the first things to be considered in ship lighting is that the conductors shall be laid in such a way as to be free from all danger of short circuit. The best way to do this is obviously to keep the two conductors a considerable distance apart. With double wires this is very inconvenient and is seldom done, the usual method of laying them being to run the pair of wires in a double grooved wood casing, the casing frequently having to be cut away at joints and crossings until there is nothing left between the two wires but the insulation. With the single wire system, on the other hand, with a little management it is generally a matter of no difficulty to keep the wires at a respectable distance from the iron of the ship.

When purposely fitted with fuzes on the main and branch wires a single wire system on board ship gives absolute immunity from fire risk, and has the additional advantages of being so simple that it can at once be comprehended by the meanest intellect, and manipulated by the rawest of electricians.

It would be interesting to know what the experience of some of your other subscribers may be in these matters.—Yours, &c.,

October 23, 1885. REGINALD A. SMITH.

[The attention of electricians on board the numerous cable ships might be directed to the question of the action of electric light wires on the compasses, with good results.—ED. *E.*]

BICHROMATE BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I see in this week's *Electrician* that "W. N." advises the zinc rod being immersed in a solution of common salt. This is a step in the right direction in the case of batteries for electric lighting. The employment of sal ammoniac or common salt has this advantage over dilute sulphuric acid, that the expense and trouble of amalgamation may be dispensed with. One other point of interest is that a solution of sal ammoniac in the porous cell with the zinc prevents the battery from freezing. I have submitted a bichromate cell charged in this

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manner to 20° of frost without any ice being produced. Dilute sulphuric acid freezes very readily. The knowledge of this fact may perhaps be useful where bichromate batteries are employed for telegraph purposes in countries liable to frost.

I notice also that Prof. Dolbear claims having discovered the advantage of sal ammoniac. A glance through the patents for galvanic batteries during the last two years would show that he was not the first to employ it.—Yours, &c.,

Derby, Oct. 27, 1885. R. FREDERICK YORKE.

INFORMATION WANTED.

TO THE EDITOR OF THE ELECTRICIAN.

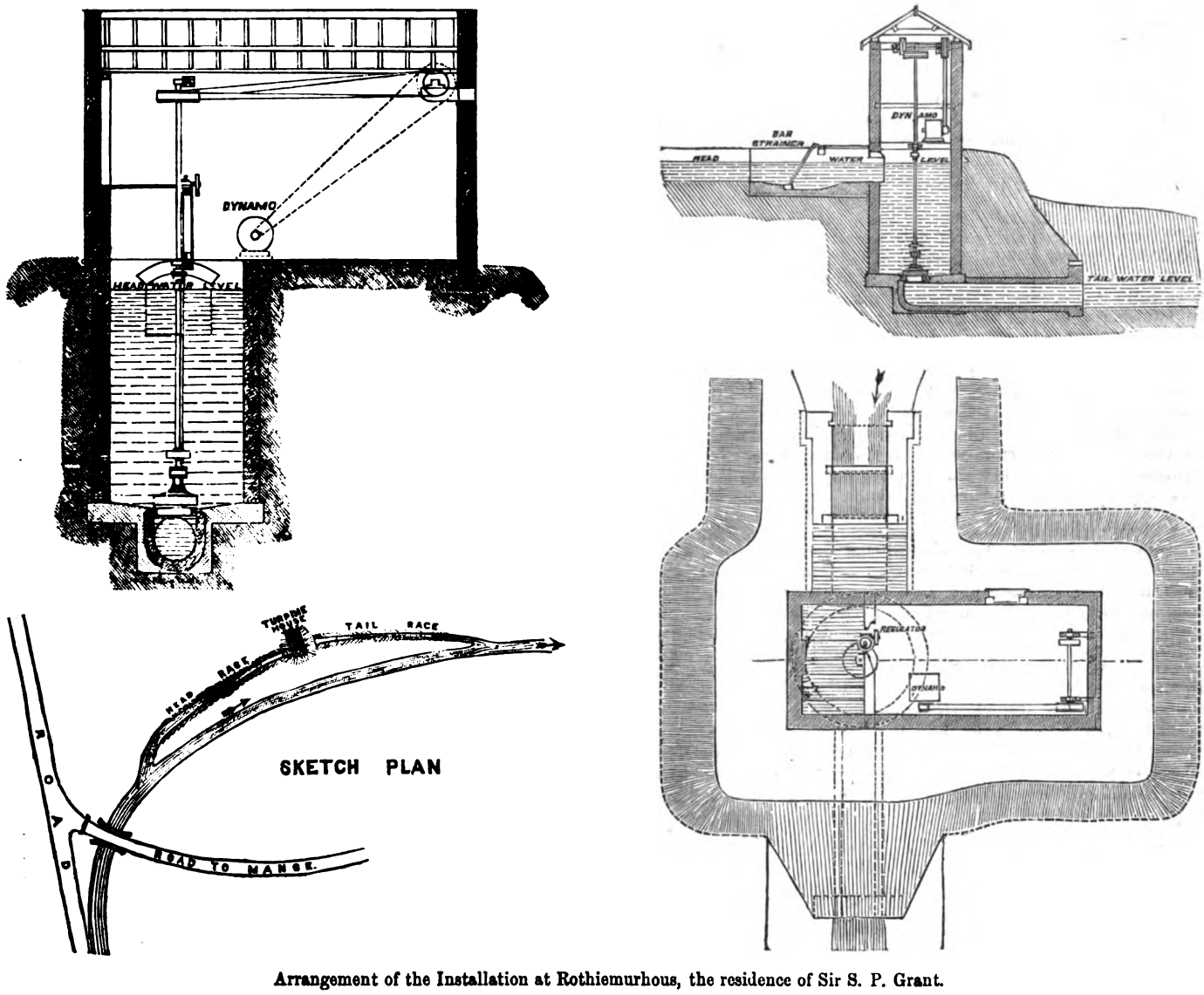
SIR: Would you do me the great favour of inserting in your valuable paper the following query?

Can you or any of your correspondents supply me with any information concerning a new Hungarian invention, which one of our leading electricians considers is to supersede all the present systems of electric lighting?—Yours, &c.,

ELECTRICIAN.

ELECTRIC LIGHTING IN THE HIGHLANDS.

We herewith illustrate the arrangement of the apparatus employed to light the residence of Sir S. P. Grant, of Rothiemurhous, situated on the Spey, near the foot of the Grampians. This installation has lately been carried out by the firm of Messrs. Craven and Elworthy. The power is obtained from a stream some three-quarters of a mile from the mansion, and is utilised by a turbine constructed by Mr. Hett, the well-known turbine builder, of Brigg. The motion is communicated to a counter-shaft and thence to the dynamo by means of belts, so that, no gearing being employed, the driving is very smooth and silent. The dynamo is of the Phœnix type, built by Messrs. Paterson and Cooper, and is, together with a switch-board and a set of 25 accumulators, placed in a suitable house over the turbine flume. The current is conveyed from the dynamo house to the mansion house by six wires. The stream which works the machinery also supplies the house with water through a 4in. pipe, and this is used as a return, thus reducing the initial outlay on the electric light mains. The number of lamps throughout the house is 80, which are of the ordinary Swan type.



Arrangement of the Installation at Rothiemurhous, the residence of Sir S. P. Grant.

The practical advantages of a turbine have been satisfactorily demonstrated, while the economy of water leaves nothing to be desired. The lights have been run direct from the dynamo without the intervention of the accumulators as an experiment, and the light remained perfectly steady. The plant above mentioned is in charge of a man who has had no previous experience of electric lighting, and as it has given satisfaction it is a convincing proof that no great obstacle is to be encountered in lighting country houses, and especially is this so where water-power can be obtained.

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ELECTRICAL ENGINEERING.

A LAMENT FOR THE ELECTRICIAN.

The profession of "Electrician" is fast assuming the unfortunate garb of too many of our trades and professions. It is already, like these, filling the advertising columns of not only its own scientific journals with situations and appointments wanted, but has found a level amongst the clerks and commercial agents seeking any suitable employment rather than find themselves without home or food. What a dreadful come-down, indeed! A profession ranking side by side and carrying the same importance as that of a civil engineer; a profession requiring a wide and varied scientific knowledge, coupled with a mathematical and inventive brain power; a profession considered perfectly suitable, and, indeed, studied by gentlemen of birth and education, to have reached such a depressed state that even those who have made its mysteries a life-long study, and taken pleasure in doing their best to advance its infant steps to strides of magnitude, now find their hopes crushed, their energies all but wasted, their livelihood quickly disappearing, and their repeated appeals for electrical appointments utterly disregarded. This not only applies to the junior members of the profession, but it is within our knowledge that men ripe in the theoretical truths of this natural, but seemingly unnatural, agent, and experienced beyond a doubt in its practical applications, past holders of important and responsible posts, are at this moment seeking work to do. Their hands, in the past used to the manipulation of telegraph instruments and other electrical apparatus, are now forcibly obliged to be idle, whilst their ready money is expended in repeatedly advertising their talents and consequent requirements. These advertisements appear and reappear, first in one journal then in another, and latterly it has been literally grieving to see that the daily advertising media have received a share of this unfortunate patronage. Unmistakably the profession has received a terrible blow, a disaster has befallen it so damaging to its young life that it now practically walks on crutches. Such a fate spreads trouble broadcast, as during the last five years the electrical profession has gained such vast importance that the time has been also prolific in the manufacture of students and practical men. These men, as electrical engineers, have found, and still find, their time fully occupied, as they can never finish or neglect to apply themselves constantly to its studies. The scope of these studies involves most engineering subjects, widening almost daily by the importation of new theories and the ever-increasing inventions for its practical applications; indeed, electricians find it impossible to be all-round men, or profess proficiency in every branch, as its thousand and one commercial industries are beyond an individual brain. Employment, time, and experience may presently prove merciful enough to attain such an enviable consummation, but specialists are now the order of the day—specialists for special branches, to the lock-out of intruders. Telegraphy and its partisans can swim along easily and successfully because of its riper years, but the newly-initiated electric light and telephony are suffering much. The telephone is chained hand and foot and hampered against competitive improvement by the iron hand of monopoly; whilst electric lighting has been nipped in its budding life and its earlier successes completely smothered by the overwhelming selfishness of a few untutored adventurers, who sought to, and did, enrich themselves at the expense of the most brilliant of domestic commodities. Necessarily its votaries are the immediate sufferers; its admirers have undoubtedly suffered by loss of money, and the general public are suffering from their general mistake. There are some engineering electricians whose pecuniary means enable them to defy commercial depression, and there are even those amongst them, unfortunately, who at this moment actually gloat over the loaded neck of the half-drowned industry, because it gives them time to advance their particular branch by strides, and to insure, perhaps, a monopoly in the future, or to raise their chances in the electrical resurrection. These find enough work, in the absence of competition, to keep them going at a fairly brisk rate. Not so the less favoured; they may starve or betake themselves into the whirling lottery for other employment. Now, what is the cause of this state of things? What circumstance is it that within this short space of time has so completely overturned the brilliant prospects of a superior profession, and been the means of beggaring many and stultifying others? The answer is—legislation and speculation. And here a short history of the progress of electric lighting up to the present, as viewed from the incidental and personal experience of one behind the scenes, and who has experienced both the bitters and sweets of the profession, will explain the disastrous influences of these two great friends or enemies of commercial progress, and amply illustrate so dire a catastrophe as a dead lock in electric lighting. Yes, truly a catastrophe! as it is not only the professional enthusiasts who are the losers, but the nation—the people. English commerce and competition are ever on the increase; continually some new theoretical problem is being thrashed into workable condition, and mental activity giving birth to new scientific applications. But in electric lighting is found a commodity which, having reached a certain critical point, received a stunning blow, the effects of which will require time and patience to overcome. Some years since American industry lent its fascinating charms to simplify and overcome the difficulties experienced in this country in the manufacture of machinery necessary for the production of the electric current, and also the means for utilising its energy. Other countries also brought assistance, until our English market was enabled to offer a fairly good assortment of dynamo machines, lamps, and apparatus, intended to revolutionise the existing lighting system, with which people had been familiar for the last fifty years. Necessarily a commotion followed. The public mind became a whirlpool, and excitement increased step by step with the advancing strides of this giant illuminating competitor. Gas shares and dividends were scrutinised, whilst its manufacture became a question of general interest for improvement. It was at this time that gentlemen's sons, finding an occupation opening to them compatible with their social standing, and embodying a professional career, sought eagerly for centres of instruction, and paid heavily in order to be first in the field. Several enterprising capitalists immediately lent themselves and their money to this evident source of profit, with the result that more would-be electricians were turned out than were even then necessary. A few *bonâ fide* corporations were hard at work doing their best to render the new scientific industry a commercial success, and employing both time and money in research simultaneously with active work. As the public confidence was yet wanting, few installations were made, and these few were individual and isolated, for the simple reason that customers conld only be found amongst large consumers of gas, and whose calculations taught them that a saving might be effected by the employment of a larger illuminating agent. The manufacturing districts of the midland and northern counties afforded the largest sphere for the efforts of the electrical engineer. Sheffield, for instance, at that time could boast of the greatest use of the electric light. Its enormous iron and kindred works were enabled to continue their work both by day and night; but here it is only fair to say that the commercial value of electrical apparatus was anything but perfect, and consequently its employment in these particular cases was a continual source of professional anxiety. Trained electricians were attached to these individual installations, and, as a matter of fact, found themselves well occupied in constantly adjusting some provoking portion of the circuit whose performances popped here and popped there like the caperings of a jack-in-the-box. The energies, and temper perhaps, of the electrician might well find cause for compulsory rest after a long spell of such care and anxiety daily, from perhaps four o'clock in the afternoon until eight o'clock the next morning during the coldest of winter months, continually watching that no failure placed works and workmen in darkness and danger. Such, indeed, has been experienced, and even a ladder kept ready at any moment to mount and arrange refractory carbons or sticking cut-outs.

With an extraordinary commercial foresight and adaptability, one or two particular companies, obtaining patent rights, and representing the manufacture of a specific system, hurriedly obtained quotations for their shares upon the Stock Exchange, and surprised both the electrical and commercial world by their sudden activity in preaching the surprising merits of their own wares. Enterprise and duplicity were not wanting. No trouble was spared to excite the public mind to a state of frenzy, and undoubtedly such efforts were rewarded, much to the detriment of both people and enterprise. Undoubtedly the public were duped, whilst those behind the scenes, the instigators of so foul a bubble, laughed in their sleeves. Company shares were run up and concessions sold to subsidiary companies, whilst promoters quietly and greedily pocketed a first-rate income. One or two, personally known, could pocket their thousands in a week. The stockbrokers were exceedingly busy, shares continually changed hands, money was lost and money made, until the speculative epidemic seemed to have laid a siege and so bombarded the excitable commercial susceptibilities of the business man that no room was left to listen to the warning voice of the reasoning electrician, who foresaw the imminent evils of such precipitate action. The sequel followed, a review of which commenced with the subsidiary companies being thrown for the first time upon their own resources. To find legs wherewith to stand appeared to be a matter of great difficulty to not a few of them after the vast expenditure entailed in the purchase of the right and its conveyance. Starting with brilliant hopes, excited determination did much to render those in office obdurate to the difficulties before them. Such matters had not been considered, and there was not time now to look at the stern matter-of-fact duties that lay before. In some cases a large amount of capital was spent in building central stations with the idea of supplying householders with domestic electric lighting from the one centre, and upon the same mains as the public lighting of the streets, whilst others wasted their substance in some other imprudent or riotous commencement to their existence. It must have

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come upon them as a depressing fact that, coincident with their finding out the many difficulties with which they had to contend, arising partly from the incomplete condition and unsuitability of their electrical apparatus, and the want of money, the public enthusiasm seemed to be abating, that the quotation of shares was gradually ebbing out its life, and that the great speculation agitators, finding their game played out, were taking back places and otherwise finding refuge in obscurity. Then, and not till then, came upon these subsidiary companies the realisation of their position ; foundations built on the sand, with not even a pecuniary backbone as a prop ; public enthusiasm dead ; scientifically insufficient and inefficient tools to work with ; a onesided and unworkable Act of Parliament of rights and restrictions, and no money ; a chaos of disasters, being a death blow to any enterprise whatsoever. Failure followed, and, one by one, each found its way into the list of voluntary or compulsory liquidations ; and as a calm always succeeds a storm, so a terrible period of inactivity in the electric lighting commercial industry has proved no exception to the rule. For the last two years the majority of electricians have found their services immensely at a discount, and many have even had difficulty to subsist. Of the public installations, which had been almost considered as permanencies, some have died, and others are gradually disappearing. Even the Thames Embankment falls back upon its old friend and faithful servant, whilst the City lighting has resolved itself into a few straggling and struggling old type, perhaps half-discarded, Brush lamps. Into what a state of collapse has it descended ! Into a bottomless pit ? Well, hardly as far as that. Resuscitation has yet a chance, and will step in ; but when ? is the question.

THE DISTRIBUTION OF ELECTRICITY.*

BY PROF. GEORGE FORBES.

LECTURE II.

(Continued from page 460.)

Multiple Tree System.—I will assume that all lamps are of the same pressure. In this case, the size of conductor per 1,000 amperes being fixed, the engine driver regulates the pressure by telegraphic indications of the potential at the nearest and farthest lamps. Compensated galvanometers may be introduced in the engine house to indicate the potential of distributing boxes, when variable currents are flowing.

Our first tree system extends to a distance of 124 yards ; beyond that we must have a second tree system with feeder mains to a distributing box, from which branches go out to supply a district, no part of which is more than 124 yards from the distributing box, or less than 124 yards from the station. From these distributing boxes a pair of thin wires

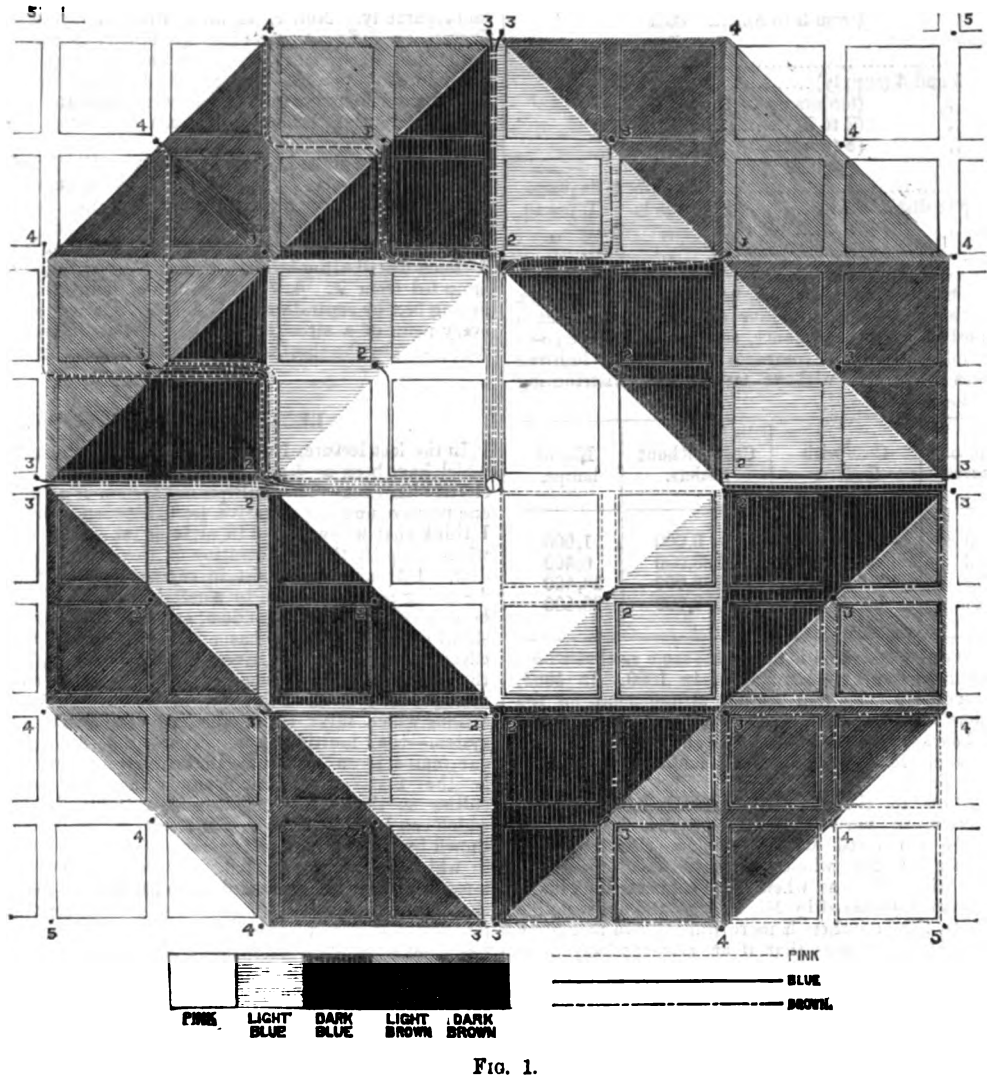

FIG. 1.

124 yards is the limiting length of conductor. Now notice that this is not necessarily the limiting length of conductor from the station, because it does not much matter what the fall of potential from the station to a lamp is ; but it is the limiting length of conductor between the farthest and the nearest lamp, or the difference in length of conductor to the station from the farthest and nearest lamps ; for here the injurious variation of potential comes into play. If the nearest lamp were 124 yards from the central station, there would be a loss of potential of 4 volts in that distance, in order to comply with economical considerations, but that loss of potential would not affect the potential between different lamps, if might go to a voltmeter in the engine house, an end of each wire being attached to the mains in the distributing box. With a similar tell-tale coming from the most distant lamp of the system, the engineer knows exactly what pressure is required. This second district, with feeder mains losing four volts, is generally larger than the first, and will generally require a number of feeder mains, or roots, feeding separate trees. It will be noticed that each root is connected to a separate dynamo. If we extend the distance still further we must put on a new set of roots or feeder mains, each losing eight volts ; and so on up to any distance. The further we go the greater is the cost of mains, but this cost is more nearly in proportion to the distance than to the fourth power of the distance, as in Mr. Kapp's paper (which is not founded on the economical considerations).

I must here put in a warning, necessary from what I have seen of the

* The Cantor Lecture of Professor George Forbes, delivered on February 9th, 1885. From the *Journal of the Society of Arts.*

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practice of this system here and abroad. The distributing box of a feeder must not be in the centre of the district supplied by that feeder, or you waste all the extra copper going to the lamps nearer to the station than the distributing box. The point of distribution must be the point of the district nearest to the central station, in order that we may have a maximum economy of copper.

Suppose we are lighting a town like Philadelphia or Chicago, which is built in square blocks, and suppose two sides of each square are 124 yards long, we should have a fed centre for each block on the diagram below where 1 is the central station. Within the square indicated by Fig. 1, no feeder mains are required. The distance of all the points 2 from the station is the same if measured along the streets. There are four squares and eight half squares thus supplied, equivalent to eight squares. The first feeder main supplies the district between the squares marked 2 and 3 respectively, equivalent to twenty-four squares ; the second set of feeders supply forty squares, the third fifty-six, and so on. The copper in the service of a block is one-half of the copper in 124 yards of the feeder main for a block, since some supply conductors are short, and others 124 yards long. Thus, to supply twenty-four squares with the first feeder, the latter must have the copper of supply conductors for forty-eight squares. In this way we find the cost of supplying the districts up to 1, 2, 3, &c. Let L be the cost of copper for one square :—

Cost for district 1 is	8L	for 8 squares.
,, between 1 and 2 (supply)	24L	
,, ,, (feeders)	48L	
Cost of district 2.....	80L	for 32 squares.
,, between 2 and 3 (supply)	40L	
,, ,, (feeders up to 2).	80L	
,, ,, (from 2 to 3).....	80L	
Cost of district 3.....	280L	for 72 squares.
,, between 3 and 4 (supply)	56L	
,, ,, (feeders up to 2).	112L	
,, ,, (2 to 3)	112L	
,, ,, (3 to 4)	112L	
Cost of district 4.....	672L	for 128 squares.

Cost of lighting square up to distance.....	124 yards	is	L per sq.
,, ,, ...	2×124 ,,		2·5L ,,
,, ,, ...	3×124 ,,		3·8L ,,
,, ,, ...	4×124 ,,		5·25L ,,

It will be seen, then, that the cost does not, in this system, vary in a proportion even approaching the fourth power of the distance, but is much more nearly proportioned to the distance, especially when we go to great distances. The following table compares the cost of lighting districts of various sizes with and without feeders and distributing centres :—

—	No. of squares.	Cost with feeders.	Cost without feeders.	No. of lamps.
1 district	8	8,000	8,000	1,600
2 districts.....	32	90,000	128,000	6,400
3 districts.....	72	280,000	648,000	14,400
4 districts.....	128	672,000	2,048,000	25,600

The system which I have now described is nearly the same as that which was proposed (in an imperfect form) by Mr. Edison in 1880. In 1883, Mr. R. E. Crompton proposed a somewhat similar arrangement for the Victoria provisional orders (also imperfect). As shown before, telegraph wires from distributing boxes (proposed by Mr. Edison) are unnecessary ; a compound-wound galvanometer attached to the mains in the engine-house serves the same purpose.

I would draw attention to the fact that the ends of the twigs, or the branch conductors, in parts of a district fed by different roots or feeders, may be connected when they are close together, thus making a network of the whole district, the proportions of conductors remaining the same as when not connected. This is a distinction from the network proposed by Mr. Edison, and a distinction necessary for economy. In this case there is more difficulty in managing the potentials, but it has this advantage, that if an accident happens to one feeder main its fed district will, in some cases, be not quite in the dark. Considering the comparatively small chance of accident to feeders, as shown by our experience of gas, I would waive this, and in some cases I might even prefer that each block should be supplied from its distributing box by independent wires to each lamp. The potentials of all lamps are then absolutely constant, and, as shown before, there is less waste of energy in the distant lamps. At Paddington Mr. Gordon uses a modification of the independent wire system by leading a group of wires for a main, and cutting out more or less of them automatically, or by signals from the engine house, according to the proportionate consumption in different parts. This is one example of many devices which the engineer may resort to in special cases, but which are not satisfactory as a general system. The different potentials may be given to the mains in a variety of ways. Edison puts resistances in the feeders. Gordon does the same by cutting out some conductors of the main feeders. I prefer, after getting 100 volts, to add to the pressure by a number of dynamos of large quantity and only two volts pressure. Terminals come to studs, along which feeder contacts slide till the right pressure is attained.

I have not time in three lectures to go into all these details. I must stick to the main question.

Network Mains.—I now come to the network system, and after the care we have bestowed upon the multiple arc system generally there is not much to say. In the form proposed and carried out by Mr. Edison it is not economical, and I shall show you why. He leads his conductors along the face of each block of buildings, and wherever the conductors intersect, the + and − conductors are connected together respectively. Distributing centres are provided with feeders supplying them, and with wires to the engine house to indicate the potential. Resistances are introduced into the feeder circuits to equalise the potentials. This is a beautiful idea, carried out without calculation, and consequently not economical. It is verbally identical with what I have called the tree system, with the branches of separately fed districts connected. The chief practical difference is that Mr. Edison lays his conductors of the same size for a long way. In the tree system the economical size of conductor is chosen in every part. Secondly, Mr. Edison equalises potential by resistances in the mains, which is hostile to economy. The importance of having a large number of feeding boxes and feeders is very great, for two reasons : —1. Repairs are more easily executed with less interference to many people. 2. The equalisation of potentials may be made practically perfect.

The advantages of independent wires from lamps to distributing boxes are enormously increased by the fact that repairs do not affect other lamps. The only consideration to weigh against its advantages is the extra cost of thin insulated wires. This is a matter which it is impossible to touch in a general statement of the problem, but which the engineer must calculate for every special case before finally deciding. The only advantage of connecting separately fed districts is the prevention of darkness in case of accident to a feeder. I prefer to guard against this by splitting each feeder into two. It would rarely happen that both were damaged together, if laid separately. Notice, in all systems of laying mains, the size of conductors in different parts is proportionate to what it would be if a wire came from each lamp by the shortest route. On the wall is a diagram to show you the arrangement proposed by Mr. Edison, where you see separate dynamos connected with separate feeders, going to separate distributing boxes, which are connected to the whole network system.

My object in these lectures is to lay methods before you, not to give opinions, but it may be right that I should state to you my belief that the most satisfactory multiple arc system proposed is as follows :—1. A large number of distributing boxes as follows (the number depending on the type of dynamo, or *vice versâ*). 2. Each box fed by a different feeder. 3. Each distributing box must be nearer to the central station than any lamp fed from it. 4. Small groups of lamps to be fed from the distributing box by separate wires. 5. The relative section of conductor at every point of a street to be the same as if every lamp had a separate wire going by the shortest street route to the central station.

LECTURE III. (Delivered Feb. 16).

In the last lecture, I was engaged in describing the different methods which have been used to apply what is called the multiple arc system of electric lighting. The multiple arc system is a system in which there are one positive and one negative lead, between which the lamps are placed. I think that we succeeded in arriving at several very general conclusions which simplify the consideration of the manner of laying mains a great deal. I think I am right in saying that in the past the practice of designing mains has been to a certain extent haphazard ; the mains have been selected a little at random, and then perhaps afterwards adjusted to a slight extent ; but there has not been that thorough estimating of the effects which could be arrived at by calculation, and in consequence of that there have been some grievous failures in electric lighting on the multiple arc system. I think we arrived at one or two important generalisations which must be accepted as necessary for economy, and in such a system—the multiple arc system—the amount of copper used in our mains is so enormous that everyone must admit that economy is the first consideration, and that all such engineering difficulties as there may be must be met by the engineer as difficulties which can be conquered. The results which we arrived at were clearly shown by the diagram of the city of Chicago, as we chose to call it, in which it was shown that, in order to have good distribution, there must be no great variation of pressure in the mains, electric pressure in the mains corresponding, as you will remember, exactly with hydraulic pressure if it were a service of water ; and in order to prevent our having too great a variation of pressure in different parts of the district, or in the same district at different periods of the night, when the consumption over the district varies, it is necessary, as I showed by means of the diagram, to have a large number of distributing boxes with mains, trunk lines of conductors coming to these distributing boxes and feeding them, and each one of these distributing boxes then serving to light up a certain space, which in the diagram is essentially a triangular space. And I also gave you the rules for determining what is the size of the district which may be lighted up by such a distributing box, and I think everyone here will agree with me that the limit was very confined indeed, compared with the general ideas which have prevailed as to the number of distributing boxes which are required ; that is to say, that upon the assumption upon which we have been working of the size of conductor required to carry a certain current, we concluded it would be necessary to have the distributing boxes so close that no lamp should be at a greater distance than 124 yards from the distributing box. Another important point which has been, I may safely say, altogether neglected in all schemes which have been hitherto issued for distribution of electricity from central stations is this, that the distributing box, the point from which the distribution takes place, must be closer to the central station than any of the lamps which are fed by that distributing box. As a

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general rule, the distributing box has been put in the centre of the district which it feeds, and that is a mistake; it ought to be nearer the central station than any of the lamps which it feeds. I gave you also in the last lecture some account of the relative cost of different systems of lighting in the multiple arc way, and it was found that by introducing a large number of distributing boxes in this way the cost was very materially reduced; but, at the same time, the cost was very great, even with these distributing boxes. And the cost may be divided into two parts; first, the cost of the supply wires, the conductors which are supplying the electricity from each distributing box to the houses, which are represented by the square lines round each block of buildings; and secondly, there is the expense of the feeders, the conductors going up to the distributing boxes. Now, when we increase the size of our district to any considerable extent, the cost of these feeders, these trunks which carry the electricity to the distributing boxes, is far greater than the cost of the supply system of conductors. If there be a means of reducing the cost in this way—that is to say, any way of cutting out these feeding conductors, that will be a very great economy indeed. This evening I will leave altogether apart the system of multiple arc lighting, which is the system which has been almost universally adopted in the past, and I shall speak this evening about the different systems which have been proposed and carried into effect for using higher pressure in the mains. The work which is done by a certain number of lamps is a perfectly definite amount of work, and it is measured by the product of the pressure of the electricity into the quantity of the electricity which flows. If we increase the pressure, we diminish the quantity of electricity that flows; that is to say, we diminish the current, and if we diminish the current, we can diminish the size of our conductors.

Now a great deal has been talked about the danger of introducing high pressures in electric distribution. I think that I shall find general agreement among competent people when I say that a great deal of what has been talked in this way is pure nonsense, and that high pressures are not in the least more dangerous than our present systems of illumination; that if we have to bring high pressures of electricity through a district those pressures are confined to the wires, and it is only in the case where there is disgraceful negligence of duty, and a disgraceful leakage towards the earth in some part of the system, that it is possible for anybody to receive a dangerous shock from the wires of such a system.

(To be continued.)

LEGAL.

United Telephone Company v. Bassano.

In the Chancery Division, on the 26th inst. (before Mr. Justice North), Mr. ASTON, Q.C., said it had been arranged that the trial of this case should stand over until the appeal had been heard in the case as to which the learned judge had already given judgment, but had not yet stated on what reasons the judgment was founded. This case would stand over until the decision of the ultimate Court of Appeal in the action on the Edison patent. The plaintiffs were to be at liberty to apply to have the case restored to the paper if the appeal was not proceeded with in due time. If, on the ultimate appeal, the learned judge's judgment should be upheld, the defendant's would submit to that judgment on similar terms in respect to the present action. If, however, that judgment should be reversed, the plaintiffs might proceed with this case in the usual course; the existing undertaking not to manufacture, sell, or dispose of the instruments complained of was to be continued until the hearing of the appeal.

The JUDGE said he failed to understand the object of this application; but if the parties had agreed to the arrangement he would not object to it.

Mr. PLUMTRE asked that the stay of execution should be continued.

It transpired, however, that no notice had been given of this application.

Mr. ASTON said he would prefer that no motion of this kind should be heard until after they had been favoured with the grounds of the judgment.

The JUDGE said he could not prevent notice of motion being given.

Ultimately it was arranged that notice of motion should be given by Thursday, the 29th inst.

On Thursday Mr. BIGHAM, Q.C., applied for an order to stay the inquiry as to damages and the taxation of costs in this case pending the appeal.

The JUDGE: What special ground is there for departing from the usual practice?

Mr. BIGHAM said the ground was that there was a *bonâ fide* intention to appeal, which the defendant was prosecuting with all diligence. The appeal was set down on 23rd September, and it was No. 101 on the list, so that it would probably come on within two months. Under those circumstances it was undesirable to have an inquiry at present into the costs.

The JUDGE said it might be convenient if the matter was adjourned, but it was entirely a matter for the decision of the plaintiffs. He saw nothing exceptional in this case. The order would be the common order as to taxation of costs.

Mr. ASTON, Q.C., said it was not necessary to get an order to stay the inquiry into damages in this case.

The JUDGE: You had better draw up no order at all at present; and make the costs of this application costs in the cause.

London and Provincial Electric Light and Power Generating Company (Limited).

Mr. ROMER, Q.C., applied to Mr. Justice Chitty for Mr. Gaminara in this case, which it had been arranged should be taken as a test case, for the removal of his name from the list of shareholders of this company. Mr. Gaminara was a general merchant, living at Upper Norwood, and he applied for and obtained immediately upon the registration of this company in May, 1882, fifty shares in the company of £5 each. He took the shares upon the strength of the statements in the prospectus that the company had acquired the patent rights of the Chertemps arc lamp for the United Kingdom; and of the lamp itself they said it "is well known for its brilliant white light, for its steadiness, and for its simplicity," and "the feed of the lamp is so sensitive that, while giving the maximum amount of light, it follows exactly the consumption of the carbons." The idea conveyed by this was that the lamp did not flicker. The applicant claimed that there were six misrepresentations in the prospectus, but that the one quoted was the principal one, and he had filed an affidavit to the effect that this allegation about the feed was untrue. Affidavits had been made by several electrical engineers, including Mr. G. C. Offor, Mr. A. J. Howes, and Mr. H. F. Joel, saying that the statement in the prospectus was misleading and untrue; that the lamp was fed by clockwork, consequently the consumption of the carbons was irregular; that the lamp varied in intensity, and necessarily flickered. Mr. G. H Redwood, the secretary of the company, had filed an affidavit in reply, saying that by the paragraph in question in the prospectus, "it was meant that, owing to the excellent construction of the lamp, the light thereby generated was, as compared with that generated by that of other companies, of uniform quantity and intensity." This was not how Mr. Gaminara understood it; and he (Mr. Romer) urged that the true meaning was that which Mr. Gaminara attached to it, and which had been proved to be untrue.

Mr. INCE, Q.C., contended that there was no misrepresentation. It was not stated in the prospectus that the lamp would not flicker; but, on the other hand, no evidence had been submitted to show that the lamp did flicker. The allegation in the prospectus was perfectly true; the feed was such as to preserve a uniform distance between the points of the carbon as they were consumed. Even Mr. Offor, in his affidavit, admitted this. The carbons adjusted themselves as the consumption went on.

The JUDGE said this was all only statement by counsel, which was not supported by evidence.

Mr. INCE said it was sufficient to point out the discrepancies in the evidence on the other side, and he read the affidavits in considerable detail. All Mr. Joule said was the feed was not sufficiently sensitive to prevent occasional flickering; the company never said that it would prevent occasional flickering. They only said that the lamp gave a more steady light than one not supplied with the feed. The clockwork responded to the electrical condition of the carbon points.

The JUDGE: Yes, but the other side says that it does not respond quickly enough.

Mr. INCE said this involved no misrepresentation. The company in the prospectus expressed the full belief.

The JUDGE: The remarkable thing is that you give no evidence to show that that statement is true; you do not show that you have tried the lamp and find that it is as you state in the prospectus.

Mr. INCE said his second point was that there had been delay. The application for the shares was made in May, 1882, and the summons was taken out in January, 1883; the applicant had made no statement as to when he discovered the misrepresentation, but in any case he had delayed too long.

The JUDGE said this was the more important point. He had known a delay of six weeks to be fatal in a similar case.

Mr. ROMER said the applicant repudiated the bargain to the secretary of the company at once, and when told the company would proceed against him, he expressed his readiness to receive a writ; but no proceedings were taken.

The JUDGE said it was clear that the alleged shareholder repudiated within a reasonable time. There was no ground for saying that he must fail on the score of delay. It was a case of simple misrepresentation, of an innocent kind so far as fraud was concerned, but sufficient to enable a person who had acted upon it, if it turned out to be untrue, to ask to be relieved from the consequent responsibility. There was no question that the statement in the prospectus was material, and that it induced the present applicant to enter into the contract. The statement was that the feed "follows exactly the consumption of the carbons," and the scientific evidence for the applicant showed that no arc lamp could be so constructed as to accomplish this. He (the Judge) had come to the conclusion that the words, taken in the natural sense, were untrue in point of fact. The applicant's name must therefore be struck off the list of shareholders.

COMPANIES' MEETING.

Brazilian Submarine Telegraph Company.

The twenty-fourth ordinary general meeting of the shareholders of this Company was held at the Cannon-street Hotel, on the 29th inst., under the presidency of the Right Hon. Viscount Monck.

The SECRETARY (Mr. Richard Collett) read the notice convening the meeting and the minutes of the last meeting, which were confirmed.

The CHAIRMAN said he would congratulate them and himself on the Company having attained a round dozen of half-yearly meetings, that being their 24th half-yearly meeting, and he hoped that the meetings had been satisfactory on both sides of the table. The report of the Directors contained in itself almost all the information that he could give them if

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he spoke to them for hours. But there were one or two observations he would like to make. A fault had developed itself in the Madeira-St. Vincent section, but it did not interfere with the execution of the work by the cable. A diminution of insulation had also taken place in the Lisbon-Madeira section, but that was exactly of the same character as the other. Both those faults were in the old cable, which had now been down for a dozen years, and with those exceptions their property was in a perfectly satisfactory state. He regretted to say that their income last half year had been about £7,000 less than that of the preceding half year. That was due to the depression of trade prevailing everywhere, the competition of the West Coast of South America line, and also the adverse rate of exchange, which had affected them in bringing their money from Brazil. It was very satisfactory to say that they had reduced their expenses by £2,077, and notwithstanding the diminution of their income they were still able to pay a dividend of 6 per cent., and carry over a respectable balance for next year. They had to regret the death of Senor Santos Silva, who had been their reprensentative in Lisbon, and under the Articles of Association of the Company they had elected the Duke de Loulé. Those were all the points which it was necessary for him to touch upon connected with their own enterprise. But he would like to allude to a matter affecting cable property generally. They knew, and other companies knew by more disagreeable experience, that cables were constantly stopped in shallow water, sometimes from wilful injury done to them and sometimes from accident. That subject had become the ground of a convention between the Great Powers interested in cable property, and the result had been an agreement entered into by all those Powers for the protection of property of this description, and anybody who now wilfully injured cable property would be liable to be punished. That was something gained certainly, but he thought it would be quite possible to have a convention which would protect their property in time of war, as well as in time of peace, against injury. Of course, no one would for a moment imagine that belligerents would consent to cable operations being carried on in time of war, but he thought the property might be protected if traffic were suspended during warlike operations. He thought that the step which had already been taken was in that direction. He concluded by moving the adoption of the report and accounts and the declaration of a dividend of 3s. a share, making, with the interim dividend, 6 per cent. for the year, free of income tax.

Sir JAMES ANDERSON seconded the motion, and testified to the value of the services which had been rendered to the Company by the late Senor Silva.

In reply to Mr. JOHN NEWTON,

Sir JAMES ANDERSON said that Mr. Fuller had more especially represented the Company at the late Conference at Berlin, but as nothing material had occurred affecting their Company, Mr. Fuller might not perhaps care to reply. He (the speaker), however, might say that a great effort was made to get this Company to reduce their rates, but that did uot appear to be the desire of their friends of the Western and Brazilian Company or of the Brazilian Government, and the rates remained as they were; but the whole tendency of these conventions was to reduce rates. There was one phase of the question which it was just as well the public should know. All the Governments of the world, with two exceptions, had a large deficit in working their telegraphic system; but notwithstanding that Germany was determined to have them made larger deficits still, and that had resulted, so far as the European traffic was concerned, in a reduction of as much as 4 per cent. in the European tariffs. When they began to discuss matters at the Conference, the expression *cables de luxe* was tabooed, but another expression arose, namely, that there were certain cables that were called "the normal way" for telegrams, and it was generally agreed that those cables should be supported, and that the tariff should not be taken for them to the enormous extent proposed. When they first went to Berlin the majority of the States fell in with that view, and the result had been that the Cable Companies had not been obliged to reduce their tariff to anything like the extent which was wished at first, and they had managed to get the rates kept up to a fair amount, particularly if the traffic increased as a consequence of the large reduction which the European States had made in the tariff. At first it appeared as if the Eastern Company, with which he was most concerned, were going to lose £40,000 a year on their European traffic alone. But he did not believe that in the two years they would lose anything, and on the face of it the loss came down to something like £12,000. At the former conferences the feature was that telegraph systems ought to pay, but he regretted that that was not the case now, the feature in the minds of the European States, especially of Germany, being that that was a secondary consideration, and that if the telegraph administration was fused with that of the Post Office they need not care what they lost in one department, because the other would make it up, and they also thought that the indirect advantage derived from the increase of commerce would more than cover any loss they made on the telegraph administration.

Mr. NEWTON said that what had just been stated had confirmed him in the view he had always taken as to the importance of keeping up their reserve fund.

The resolution was then unanimously carried.

On the motion of the CHAIRMAN, seconded by Mr. FREDERICK YOULE, the Duke de Loulé was re-elected a Director, as was also Viscount Monck, on the motion of Sir THOMAS FAIRBAIRN, seconded by the Hon. W. ST. JOHN F. BRODERWICK, M.P.

Messrs. Henry Dever and John Gane were re-elected auditors, and the proceedings terminated with a vote of thanks to the Chairman and Directors.

COMPANIES IN LIQUIDATION.

The following notices appear in the *London Gazette*:—

The Jarman Electrical Company (Limited).—At an extraordinary general meeting of the above-named company, duly convened and held at No. 6, Great Winchester-street Buildings, in the City of London, on the 5th day of October last, the following special resolutions were duly passed; and at a subsequent extraordinary general meeting of the said company, also duly convened and held at the same place on the 22nd day of October last, the following special resolutions were duly confirmed, viz.: 1. "That the company be wound up voluntarily, under the provisions in that behalf of the Companies Acts, 1862-7; 2. That Mr. W. Smith, of 6, Great Winchester-street, E.C., be appointed liquidator for the purpose of winding up the affairs of the company; 3. "That the liquidator be authorised, under the 161st section of the Companies Act, 1862, to carry out the agreement of 31st July, 1885, between the said Jarman Electrical Company (Limited) of the first part, Chainsonovitz Prosper Elieson of the second part, and Edward Spendlove, as trustee for and on behalf of the Electric Locomotive and Power Company (since registered) of the third part, and any confirmatory agreement for the sale to the said Electrical Locomotive and Power Company of the business, property, and effects of the said Jarman Electrical Company."—G. HAMILTON, Chairman.

The Electric Sun Lamp and Power Company (Limited).—The creditors of the above-named Company are required, on or before the 4th day of December, 1885, to send in their names and addresses, and the particulars of their debts or claims, to Messrs. William Perkins, Matthew Inglett Fortescue Brickdale, and Henry de Grelle, the liquidators of the said Company, at 5, Bombay-street, Bermondsey, in the county of Surrey, and if so required by notice, in writing, from the said liquidators, are to come and prove their said debts and claims at such time and place as shall be specified in such notice, or in default thereof they will be excluded from the benefit of any distribution made before such debts are proved.—W. PERKINS, M. I. F. BRICKDALE, HENRY DE GRELLE, liquidators.

The Anglo-Continental Telephone Company (Limited).—Notice is given that a general meeting of the members of the Anglo-Continental Telephone Company will be held at the offices of Messrs. Fox and Greig, No. 22, Austin Friars, London, E.C., on Thursday, the 26th prox., at 3 o'clock, for the purpose of having an account laid before them, showing the manner in which the voluntary winding up has been conducted, and the property of the Company disposed of, and of hearing any explanation that may be given by the liquidator; and also of determining by extraordinary resolution the manner in which the books, accounts, and documents of the Company and of the liquidator thereof shall be disposed of.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. OCT. 28.		BUSINESS DONE WEEK ENDING OCT. 28. Highest.		Lowest.	
Anglo-American	32,	33	.....	33	.....	32x.d.
Do. Preferred	55,	56	.....	56½	.....	54½x.d.
Do. Deferred	8¾,	9¼	.....	9¾	.....	8¼
Brazilian Submarine	11⅜,	11⅝	.....	11⅝	.....	11⅝
Cuba	12,	12½	.....	12½	.....	—
Do. Preference	18,	19	.....	18¾	.....	—
Direct Spanish	1½,	2	.....	—	.....	—
Do. Preference	11¼	11¾	.....	—	.....	—
Direct United States Cable	9¼,	9½	.....	9¾	.....	9½x.d.
Eastern Telegraph	11⅜,	11⅝	.....	11 11-16	.....	11 7-16x.d.
Do. 6 per Cent. Preference	13¾,	14¼	.....	—	.....	— x.d.
Do. 5 per Cent. Debentures, 1899	105,	108	.....	—	.....	—
Eastern Extension	12⅝,	12¾	.....	12 13-16	.....	12 9-16x.d.
German Union	9½,	10	.....	9¾	.....	—(bonus
Globe Telegraph and Trust	7,	7½	.....	7⅝	.....	7x.d.
Do. Preference	13½,	13¾	.....	13¾	.....	13½x.d.
Great Northern	13½,	14	.....	13 15-16	.....	13¾
Indo-European	81,	82	.....	—	.....	—
Reuter's	7½,	8	.....	7⅝	.....	—
Submarine	205	215	.....	—	.....	—
West India and Panama	⅝,	¾	.....	¾	.....	—
Do. 1st Preference	8½,	9	.....	8¾	.....	8 9-16
Western Brazilian	5½,	5¾	.....	5⅝	.....	—
Western Union 7 per Cent. 1st Mortgage	120,	124	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	100,	104	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	¾,	1	.....	1	.....	15-16
Oriental	3-16,	5-16	.....	—	.....	—
United Telephone	11¾,	12¼	.....	12	.....	11 13-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1¾,	2¼	.....	2 1-16	.....	1¾
Do. (fully paid)	3½,	4	.....	3¾	.....	3⅜
Hammond Light (£3 15s. paid)	1-16	3-16	.....	—	.....	—
Swan	½,	¾	.....	—	.....	—
Maxim-Weston	3-16,	5-16	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	36,	37	.....	36¾	.....	36¼
India Rubber, Gutta Percha, and Telegraph Works	23½,	24½	.....	24¼	.....	23¾

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NOTES.

NOTICE OF REPAIR.—The cable between Fao and Bushire is repaired.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 30th ult. amounted to £3,314.

LONDON PLATINO BRAZILIAN COMPANY.—This company have declared an interim dividend of 1s. per share for the half year ended 30th September.

THE WEST AUSTRALIAN TELEGRAPHS.—It is expected that telegraphic communication with Roeburne will be completed by about the 15th of next month.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for October, 1885, amounted to £56,994, and to £53,865 in the corresponding period of 1884.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of October were £1,748, against £1,816 in the corresponding period of last year.

GREAT NORTHERN TELEGRAPH COMPANY.—The receipts of this company for October were £24,400 ; from 1st January to 31st October, £241,640; against in the corresponding months of 1884 £234,680, and 1883, £215,280.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of October amounted to £43,986, and to £41,357 for the corresponding period of 1884, showing an increase of £2,629.

THE AUSTRALASIAN CABLE SERVICE.—It has been decided that the New Zealand Government will undertake to continue the Australasian cable service for five years, provided the charge for press messages did not exceed 3d., and for ordinary messages 6d.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 30th October, were £2,558, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 31st October are £1,931, as compared with £2,512 in the corresponding period of 1884. The July receipts, estimated at £5,089, realised £5,157.

THE LIGHTING OF PICCADILLY-CIRCUS.—At a recent meeting of the Metropolitan Board of Works a letter from Messrs. Hunter, Harrison, and Co., submitting a scheme for the electric lighting of the large open spaces at Piccadilly-circus, was referred to the Works and General Purposes Committee.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of October was 2,694, estimated to produce £2,100, against 2,589 messages, producing £2,230 in the corresponding month of last year. The traffic receipts for the month of July, estimated at £2,500, realised £2,517.

AWARDS.—Messrs. Walter T. Glover and Co., of Salford, Manchester, have been awarded a gold and silver medal at the International Inventions Exhibition, 1885.—Messrs. Robey and Co., of Globe Works, Lincoln, have received a gold medal for their patent improved Robey mining engine, horizontal fixed engine, and Robey compound semi-fixed engine fitted with electrical regulator.

UNITED TELEPHONE COMPANY.—At the board meeting of this Company, held on the 3rd inst., the directors being satisfied that the position of the company justifies them in making a somewhat larger payment on account of the earnings of the current financial year than heretofore, have determined to pay 4s. on each fully-paid share (part-paid shares receiving in proportion) by way of interim dividend.

TELEGRAPHIC CONFERENCE BETWEEN ENGLAND AND THE EAST.—It is said that the Eastern Telegraph Company has asked the Dutch Government to join in the arrangement between the company and the British Government for the application, from the 1st of the current month, of the provisions drawn up at Berlin for the regulation of telegraphic correspondence between England and the East.

THE ELECTRIC LIGHT IN THE INNER TEMPLE LIBRARY.—The librarian of the Inner Temple library writes as follows to the *Daily News* :—"*Apropos* of your article on the electric light in this library, may I be allowed to say that the success of the installation is mainly due to Mr. John Clerk, Q.C., treasurer of the Inn; Mr. Arthur Cates, the architect; and to Mr. Belshaw, the manager of the Edison-Swan Electric Lighting Company."

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—The next meeting of this society will be held at the Institution of Civil Engineers, 25, Great George-street, Westminster, S.W., on Thursday, the 12th instant. There will be a council meeting at 7 p.m., and an ordinary general meeting at 8 p.m., when a paper will be read by Major-General Webber, C.B. (Ret.), R.E., past president, upon "The Telegraphs of the Nile Expedition."

THE LIGHTING OF THE CITY.—At a recent meeting of the Commissioners of Sewers, Mr. Pannell asked whether the Streets Committee had had an offer to remove an installation for electric lighting and lay the same in a district of the city for a stipulated sum. Mr. Altman, chairman of the Streets Committee, said they had had an application to remove an installation from some part of the country to London. It was now before the committee, and he hoped soon to bring up a report.

CAUTION.—Those who have visited a Spanish, Italian, or Portuguese port, will have a vivid remembrance of the extraordinary precautions against possible risk of infection taken by the sanitary "visit." The following, however, gravely recounted by a Milan contemporary, beats anything we have seen or heard of. At the time when the cholera broke out in the departments in the north-east of France, a number of Italian telegraph office officials ordered a quarantine of twenty-four hours, with fumigation, to be imposed upon all telegrams coming from the infected districts.

AN APPLICATION.—In the High Court of Justice (Chancery Division) recently, before Mr. Justice Chitty, an application was made by divers shareholders of the London and Provincial Electric Lighting and Power Generating Company for rectification of its list of shareholders by the removal therefrom of the applicants' names. It appeared that the company was incorporated in May, 1882, and was in November, 1883, ordered to be wound up. The ground of the application was that the applicants were induced to take their shares by means of misrepresentations contained in the prospectus issued by the company. Mr. Justice Chitty made the order applied for.

THE ELECTRIC LIGHT IN A LIVERPOOL CLUB.—At the dinner recently given to the Liberal candidates for the Liverpool constituencies at the Junior Reform Club, the dining saloon was lit up for the first time by the electric light, and

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presented a most pleasing and brilliant effect; the work was carried out in a satisfactory manner by Mr. W. H. Fleming, electrical engineer, of Baliol-chambers, Stanley-street, Liverpool. The motive power for driving the dynamo machine, which was an 8in. Elwell-Parker, was obtained from a gas engine situated in the basement of Baliol-chambers. Fifty Edison-Swan 45-volt 16 candle-power incandescent lamps were used.

THE LALANDE AMPEREMETER.—The new amperemeter of M. F. de Lalande is highly commended by our French contemporaries, who lay great stress upon improvement effected by the substitution of an electro for a permanent magnet. The instrument, roughly, consists of a bundle of soft iron wires placed in the interior of a metallic areometer, which latter is inserted in a gauge full of water surrounded by a coil traversed by the current to be measured. Under the action of the current the bundle of wires is attracted, and the areometer is more or less displaced according to the strength of the current indicating the value of such displacement upon a scale graduated upon the instrument

POOLE SCHOOL OF SCIENCE AND ART.—The following have obtained prizes at the above science school:—W. Bartlett, 2nd class elementary certificate for electricity; A. R. Curtiss, 1st class elementary certificate for electricity and local prize for electricity; F. B. Daniel, 2nd class advanced certificate for electricity; L. F. Davis, 1st class elementary certificate for electricity, local prize for electricity; Mrs. Gilbert, 1st class elementary certificate for electricity, local prize for electricity; A. Reed, 1st class advanced certificate and prize for electricity and local prize for same; W. Sedgfield, 2nd class elementary certificate for electricity; R. Smith, 1st class elementary certificate for electricity and local prize for electricity; E. J. Wilkins, 1st class elementary certificate for electricity and local prize for ditto.

TARDY TELEGRAMS. — A correspondent of the *Standard* writes as follows:—"I do not know what may be the experience of other people; but after three weeks of sixpenny messages I find most of them rather dear at the money. I live in a London suburb, twenty-five minutes by train from Ludgate-hill, three-quarters of an hour by cab from Ludgate-circus, and my house is so near the Post Office that I can walk to it in seven minutes. Yet it is rare that a telegram from Ludgate-circus reaches me within forty minutes, and I have received one at forty-four minutes past six which was handed in at four minutes past five. It therefore took one hour and forty minutes to travel a distance which a cab can cover in three-quarters of an hour. To my finite intelligence this looks absurd. Is the office overworked or undermanned, or is the young lady operator becoming careless?"

THE "MAGNETIC UMBRELLA."—Mr. Sprague, in a letter to us, mentions this subject as follows:—"I may say that the late accounts published of the mysterious 'magnetic umbrella' somewhat amuse me, as I possessed one myself a long while ago. When the first experiments with the Gramme machine were made in the Westminster Bridge-road, I was leaning close to it on my umbrella, and the machine being suddenly turned on the umbrella was torn out of my hand, and ranged across the field-magnets. It became a powerful magnet and remained so for years. I often puzzled people with it by setting magnetic needles spinning about by merely pointing my finger towards them, and I know that in some cases I caused a good deal of mental tremor by my apparent possession of this unusual 'magnetic moment,' the poor umbrella being of course a mere accident of the moment."

TELEGRAPH AND POSTAL ADDRESSES.—Sixpenny telegrams are already exerting their influence on business ways. The adoption of "telegraph addresses" is likely to become universal among such as carry on a large correspondence in which the use of the telegraph is constantly called in; and hence the necessity of a new or supplementary method of indexing. Messrs. Duncan Campbell and Son, of St. Vincent-street, Glasgow, have been prompt to provide for this want. They have issued a strongly-bound index of "Telegraph and Postal Addresses." One half of the volume is arranged for the alphabetical indexing of "Telegraph Addresses," followed by the names and postal addresses of correspondents. Reversing the book, the order is found reversed; the spaces under each letter are left for names and postal addresses followed by telegraph addresses. The device is ingenious and simple, and may be turned to account for more purposes than one.

ELECTRIC SIGNALLING FROM BALLOONS.—Mr. Bruce, whose experiment at the Albert Palace was noticed in our columns, has written to us to say that he has been carrying out fresh experiments at Chatham, with a view to procuring the adoption of his system for the purpose of military signalling. The official trial of the invention took place on the 19th ult., when the signalling apparatus, the balloon, was sent up four or five miles from Chatham, and allowed to ascend 500ft., a series of sentences being flashed by the Morse system. The officers of the Royal Engineers, who were deputed to inspect the apparatus, have pronounced the experiments eminently satisfactory. It has been suggested that this translucent balloon may be utilised for other military operations besides signalling, such as for a "point light" for concentrating forces by night; and owing to the wide area which is illuminated by the balloon, it has been proposed to use it for lighting working parties.

THE ELECTRIC LIGHT AT TUNSTALL.—In connection with the festivities incident upon the opening of the new town hall at Tunstall, Staffordshire, on Thursday week, a football match was played under the electric light on the Phœnix Park Grounds, a vast assembly of people being present. The grounds were effectively lit up by six Lever arc lamps. The football match was succeeded by a promenade concert in the covered market, which was attended by several thousand people. The Market Hall was illuminated by ten 2,000 candle-power nominal arc lights of the same system, and two lamps were placed outside—one over each entrance. An engine had been provided in the Soho Mills, but Mr. Lever found it desirable to hire a portable engine as well, so that the work was divided between them. This was on the 29th ult. The next night a ball was given in the Town Hall, when the front of the building was illuminated by five arc lamps. The lighting was a great success.

A SAD ACCIDENT.—We regret to have to announce that a sad accident occurred off the mouth of the harbour of St. Thomas on Saturday the 3rd ultimo. Messrs. E. Howes, the second engineer, G. Heath, third engineer, and James Day, jointer, of the cable steamer "Duchess of Marlborough," belonging to the West India and Panama Telegraph Company, were, while boat sailing, caught in a sudden squall, which filled their boat and sank it. Nothing has since been heard of Messrs. Howes and Day, but Mr. Heath was on the following Monday discovered on an island close by, after having sustained an exposure of about thirty-eight hours. Little hope is entertained for the safety of the other unfortunate men, there being every reason to fear that

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they have fallen victims to the sharks which abound in the waters of St. Thomas. Both leave wives and families to deplore their loss. Mr. Day had only recently left the service of the India Rubber and Gutta Percha Company, at whose works he was employed in the capacity of jointer.

THE FRANKLIN INSTITUTE.—The programme of lectures at this institute for the session 1885-86 has just been issued. It promises to be very interesting. On the 13th inst. Lieut. Bradley A. Fiske, U.S.N., will discourse on "Electricity in Warfare;" Prof. A. E. Dolbear on "Telephone Systems," Dec. 11; Mr. C. J. Kintner, Chief Examiner, Department Electricity, U.S. Patent Office, Washington D.C., on "The United States Patent Office Historical Electrical Apparatus," Jan. 25, 1886; Mr. Carl Hering, of Philadelphia, on "Dynamo-electric Machinery," March 1; and upon the same subject one week after that date; and Capt. Otho Ernst Michaelis, U.S.A., on "The Function of Electricity in the Development of Markmanship, or Electro-Ballistics," March 15. The lectures of the physical course are chiefly upon subjects bearing upon the International Electrical Exhibition of 1884, by gentlemen who were personally engaged in scientific work connected therewith. They have been arranged by Prof. Houston with the object of giving the members of the institute a review of some of the leading features of that important historic event.

CONTINENTAL ITEMS.—The installation recently started at the New Lyceé Louis-le-Grand, Paris, is giving great satisfaction.—The inauguration of the electric light at the Opera House, Paris, will be coincident with the first representation of "The Cid," a new opera by Massenet.—The Société Industrielle of Amiens is offering gold medals for the best designs for a new dynamometric brake and a simple and economical dynamometer. Plans may be forwarded to the president until 30th April prox.—It is said that the Société Générale des Téléphones has decided to add to its other establishments a factory for the manufacture of submarine telegraph cables at one of the principal French ports.—The yacht "Hero," belonging to M. de Rothschild, has, preparatory to her departure for Nice, been equipped with a dozen Trouvé portable incandescent lamps.—There is about to be published at the Librairie Bernard Tignol a new work by M. G. Fournier, entitled "Les Sonneries Electriques, Installation et Entretien." This will form the tenth volume of the "Bibliothéque des Actualités Industrielles."

WELL-DESERVED PUNISHMENT.—A remarkable charge was investigated before the Liverpool Justices on the 3rd instant, when Edwin Mitchell and James Hughes were summoned for having obstructed a telegraph communication of the Exchange Telegraph Company. It was stated that the company conveyed messages by means of a tape, and supplied a number of betting and other clubs with racing information. The defendants took a room above one of the clubs, and carrying the telegraph wire through the window, attached it to a brass water tap, thus stopping the electric current, and preventing the club below from receiving the news of races. Mitchell was found in possession of the room when the wires were tampered with. It is the practice of these clubs to make bets up to within three or four minutes of receiving the result of the race, and the stoppage of the messages complained of would give Mitchell time to back a winner of a race with tolerable certainty at the club where the result of the race by means of his conduct had not been received. The summons against Hughes was withdrawn. Mitchell pleaded guilty, and was fined £10 and £3. 7s. 6d. costs.

CRYSTAL PALACE INDOOR FETES.—These *fêtes* will for the present take place tri-weekly, on Mondays, Thursdays, and Saturdays. The normal lighting of the building, by about 5,000 ordinary gas-burners, and 75 large electric arc lamps, each of a nominal 2,000 candle-power, will be supplemented by 10,000 gas-jets in lamps of various beautiful hues, and 4,000 "bucket" oil lamps. The tinted glass lamps, arranged in festoons and other graceful devices along the girders and at other points of vantage in the building, have been specially manufactured at Stourbridge for the Crystal Palace Company, many of the tints being quite novel. The music will be mainly furnished by military bands, and these will play on an elegant newly-constructed decagonal orchestra in the Centre Transept. This orchestra alone will be lighted by about 2,000 coloured lamps. The electric arc lamps in the centre will be masked, so to speak, by Chinese lamps encircling them, the object being to add picturesqueness to the general scene, and to prevent the milder lights from being overpowered by the electric light. The great stage which forms the background to the scene has been decorated by Mr. F. Fenton, and represents a semi-Oriental interior. This also will be brilliantly lighted. The whole has been designed and executed by the company's staff.

THE SIXPENNY TELEGRAMS.—Although the Post Office authorities are unable at the present moment to furnish a tabulated statement showing in actual figures the working of the sixpenny telegraph system during the few weeks it has been in operation, they have nevertheless had sufficient experience of its working to satisfy the Telegraph Department as to the success that has hitherto attended the cheapened rate, and the still greater success they may fairly anticipate. Taking only the ordinary paid inland telegrams, exclusive of press and other messages of a special character, the increase during the first completed week in October reached 33 per cent., which is 3 per cent. beyond the original estimate for the entire year. During the second completed week the increase was 44 per cent.; but in the third week there was a fall in the percentage of from 44 to 39. This, however, need hardly be regarded as discouraging, inasmuch as, in comparison with the corresponding period of the previous year, the depression then experienced was considerably greater in proportion to the then charges than the slight falling off recently experienced. The average price paid for telegrams during the past month has been about 8d., as contrasted with an average under the 1s. system of 1s. 1d. Of the large number of telegrams transmitted under the reduced rate about forty per cent. are attributable to the sixpenny rate, and there is little doubt that the extra halfpence as between the minimum and the average charge have been contributed to an appreciable extent by those who as yet have had little exercise in the art of condensation. The increase of private telegrams in the metropolis has been really enormous when compared with the general increase throughout the United Kingdom, for whereas the total percentage of increase has fluctuated between thirty-three and forty-four per cent., the increase in London alone has amounted to considerably over sixty per cent. There has been a proportionate increase in several of the largest of our provincial towns, notably Liverpool, Glasgow, and Manchester.

THE PROPOSED ELECTRIC LIGHTING OF BRISTOL.—In October last year an Electrical Committee of the Bristol Corporation was appointed to inquire into the best means of lighting the city by electricity, and to invite such tenders as they might deem advisable for the supply of electricity, or for the execution of any work necessary for the purpose. The committee was also instructed to ascertain the cost to the council of laying and

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maintaining their own mains. The committee have since applied to Mr. W. H. Preece, F.R.S., who said that, although at present they could not compete in price with gas, yet that the ultimate economy was so marked that it had only to be tried to be proved. He thought the city should contemplate the use of at least 2,000 lamps. Such an installation would, he said, pay its way; and if the lamps were distributed in the best parts of Clifton, it would speedily lead to a demand for the use of electric lighting elsewhere. He had no doubt that plant could be laid down which would work with safety, surety, and economy, and maintain a constant and steady supply; and he hoped the committee would proceed with the work, and be the pioneers of a self-supporting electric light installation. The committee had received a further report from Mr. Preece, dated the 16th ult. He was of opinion that the Electric Lighting Committee of the Bristol Corporation had better apply to the Board of Trade for an extension of time. The committee had applied to the Board of Trade, asking what steps it would be necessary to take in order to obtain such extension. The Board replied to the effect that they could not prolong the time except by a provisional order confirmed by Parliament; but that, in the event of the sanitary authority not laying down mains within the prescribed period, the Board, as then advised, would not be disposed to exercise their powers to revoke the provisional order which the authority had obtained. This being so, their provisional order, and the powers under it, still continued in force. The committee thought it proper at this time to lay before the council what had been done by them, and to submit the present position of the business; also to ask for instructions as to whether they were prepared to provide the money and proceed with the works, either in the compulsory area, or on the basis of Mr. Preece's report of December, 1884, or have an experimental installation on a small area in some other part of the city and county. As an alternative, whether they would wait and see the result of further experiments in other places. The report of the committee will be considered at an early meeting of the Town Council.

The Electric Light in Kendal.—A local contemporary says that Mr. Councillor G. J. M'Kay is to be thanked for the introduction in Kendal of this much admired light in a large and practical way. "We had the pleasure recently of going through his new woollen manufactory and of seeing for ourselves the light working to perfection in all the various departments, including the offices and warehouse. It appears that Mr. M'Kay has given great attention to this light, and before placing his order visited several manufactories and mills lighted up with electricity, and also examined the various makes of dynamos. Having secured sufficient information to satisfy him, it was no longer an experiment but a realised fact that the electric light was not only better in every way for lighting purposes than gas, but had also the advantage of being cheaper than gas charged at 2s. 6d. per thousand feet, after allowing liberal interest for the first outlay and a reasonable allowance for attendance, &c. In the departments where the work was being carried on the light appeared much superior to gas, and from inquiries we made from the workpeople they preferred it to gas. They could also discern the various colours of the yarn and cloth more correctly. The electricity is produced by a Crompton new patent compound wrought-iron dynamo, and is driven by the same engine which provides power for machinery in the mill. This dynamo lights 160 incandescent glow lamps of Swan-Edison's patent, 20 candle-power each, which are spread over the various departments of the manufactory. The dynamo is capable of working 250 lights, and the main wires are laid down large enough for the remaining 90 lights whenever required. The contract has been successfully carried out under the instructions of Mr. Francis Preston, A.M.I.C.E., and M.I.M.E., consulting and electric light engineer, Huddersfield. The installation has been carried out by Mr. Wilson Hartnell, C.E., engineer and electric light contractor, Leeds. Mr. Hartnell has erected over forty installations during the past two seasons, including ironworks, manufactories, warehouses and private mansions. At the present he is lighting with 300 lamps Wentworth Castle, also the private house of Colonel Brooke, J.P., Armitage Bridge, Huddersfield. The introduction of the light into Kendal has also brought a little work into the town, as Mr. Preston has placed an order for a vortex turbine and a large quantity of cast-iron pipes with Messrs. Gilbert Gilkes and Co., of the Canal Iron Works. This turbine and pipes are required for one of Mr. Preston's installations. We are informed that Mr. M'Kay intends inviting many of the townspeople to visit his works, and to inspect the light for themselves."

Electric Tramway Engine.—An Essex contemporary is quite enthusiastic in the praise of the C. P. Elieson's patent electric tramway engine, which has for some time past been tested and run at the works of the North Metropolitan Tramway Company, Union-road, Leytonstone. The engine will be removed in a few days to the Stratford Depôt, whence public trials will be made. It appears that an extension will shortly be made of the tramway from Stratford down the Ilford-road, and that arrangements will be made later on to work this portion entirely by electric engines. Meanwhile an engine of greater power is being constructed, with the view of showing what can be done on a railway. The following special advantages are claimed for the engines, which are of the regular pattern:—1. They can be placed upon any existing line of tramway where horses are employed without interfering in any way with the arrangement of the cars on the permanent way, and the electrically propelled cars can run alternately with horse cars where required. (2.) The cost of an installation of charging station and locomotives to replace horses is considerably less than the cost of the horses, harness, and stabling, while the maintenance is quite forty per cent. less. (3.) The apparatus is perfectly under the control of one attendant, who need not be a skilled electrician. (4.) The cars or carriages can be splendidly illuminated by the same current of electricity that supplies the power to the locomotive, the fraction so used being inappreciable. (5.) The enormous tractive force developed by the special electric locomotives which the Electric Locomotive and Power Company propose to manufacture, enables the traction upon railway lines, where smoke and steam are objectionable and prejudicial to the health of passengers, to be carried out electrically with economy. (6.) The absolute safety of the system, the low tension current employed being perfectly harmless. It may be interesting to state that the maximum of speed developed in the engine under notice is about eight miles an hour, but if necessary an engine can be constructed to run as slow or as fast as may be required for all practical purposes. The power is derived from 50 cells, containing about 280 amperes, and the current used varies from about 60 amperes per hour at starting to about 35 amperes per hour when running. It will therefore be seen that a continuous run of about six hours, at an average of 40 amperes per hour, is secured without exhausting the stored electricity. Great improvements have been, and are being, made in storage cells, and there is not the slightest doubt that in the future cells of greater capacity will be constructed, thus enabling an engine to run for several hundreds of miles without recharging.

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THE DETERMINATION OF CURRENTS AND RESISTANCE IN A NETWORK OF CONDUCTORS.

(Concluded from page 469.)

Maxwell's second theorem here quoted is "to determine the capacity of a condenser by means of a Wheatstone bridge."

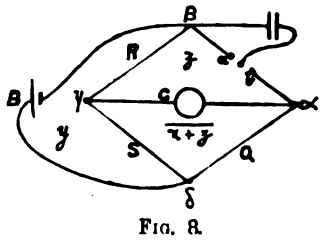

FIG. 8.

Let α, β, γ, δ be the four points of a Wheatstone's bridge, and let the branch between α and β be interrupted at a b, and a Leyden jar or condenser inserted, provided with some rapid commutator, such as a tuning fork, so that whilst one pole of the condenser is kept permanently attached to β the other is alternately joined to a and b.

* * * * * *

Now let the meshes of the network be called $x+z$, z, and y; then x is the current through the galvanometer and y is the current through the battery. When the fork is set in vibration, the commutator and the condenser act together like a resistance, and let through so much electricity per second.

Now, as the condenser gets its charge by electricity flowing into it, it builds up an opposing electromotive force in the z circuit, which at any instant is equal to the value of $\int \frac{z\,dt}{K}$, where K is the capacity of the jar the integral being integrated from the instant when the charging commences up to the instant considered. Now, if the commutator makes n vibrations a second when the steady state is set up, the current z which flows into the jar has a mean value, z; and therefore $\frac{z}{nK}$ is the opposing electromotive force in that branch.

The condenser and associated commutator behave like a resistance in the branch $\alpha\beta$ with a counter E.M.F. in it. Only such a combination differs from an ordinary metallic resistance in this, that its apparent resistance is not constant, but depends on two things—the speed of commutation, or charge and recharge, and the capacity of the condenser; whilst the counter E.M.F. depends not only on n and K, but also on the current z, and therefore on the resistances of the other branches. We require an expression for the E.M.F. charging the condenser. Let the difference of potential between a and b be called e. Then consider the network formed by the five conductors, R, S, Q, G, and B, with the electromotive force in the branch B; write down the net-work equations for this two mesh network

$$(B+R+S)\,y - S\,(x+z) = E$$
$$-Sy + (Q+S+G)(x+z) = 0$$

[The commutator is supposed not to be in action, consequently the branch $\alpha\beta$ is interrupted, and the cycle current z is equal to zero.]

We obtain $$y = \frac{E\,(Q+S+G)}{\delta}$$

and $$x+z = \frac{ES}{\delta}$$

where δ = the determinant.

$$\begin{vmatrix} B+R+S, & -S \\ -S, & Q+S+G \end{vmatrix}$$

which is $$S\,(Q+G) + (R+B)\,(Q+S+G).$$

Now, the difference of potential e between a and b when the condenser is just beginning to be charged is

$$G\,(x+z) + R\,y = e.$$

[This will be seen by writing the network equation for the z cycle with $z=0$.]

$$\therefore e = \frac{E\,S\,G}{\delta} + \frac{E\,R\,(Q+S+G)}{\delta}.$$

Now, if the electromotive force e be employed n times in a second to charge a jar of capacity K, the average current flowing into the jar is $nKe = z$.

Now, to find z we have to consider the distribution of currents when the fork or commutator is in operation, and the condenser allowing a flow of electricity to take place through it.

Let P be the resistance which could equivalently replace the jar and fork—that is, would allow an equal quantity of electricity to pass per second; then since $\frac{z}{nK}$ is the opposing electromotive force in this branch, we have an equation for the three cycles z, $x+z$ and y [which after rearranging becomes]

$$-Sz + (R+S+B)\,y - (R+S)\,z = E$$
$$-Gx - Ry + (P+R)\,z = -\frac{z}{nK}$$
$$(Q+S+G)\,x - S\,y + (Q+S)\,z = 0$$

Now let Δ stand for the determinant

$$\begin{vmatrix} -S, & R+S+B, & -(R+S) \\ -G, & -R, & P+\frac{1}{nK}+R \\ Q+S+G, & -S, & Q+S \end{vmatrix}$$

Then the solutions of the above equations for z and x are

$$z = \frac{E\begin{vmatrix} -G, & -R \\ Q+S+G, & -S \end{vmatrix}}{\Delta}$$

and

$$x = \frac{E\begin{vmatrix} -R, & P+\frac{1}{nK}+R \\ -S, & Q+S \end{vmatrix}}{\Delta}$$

z is the average current flowing through the condenser, and x is the current through the galvanometer. Now, let the resistances R, S, and Q be so varied that the current through the galvanometer is zero, then $x=0$, therefore

$$\begin{vmatrix} -R, & P+\frac{1}{nK}+R \\ -S, & Q+S \end{vmatrix} = 0.$$

Now insert this value for $P+\frac{1}{nK}$ in the determinant Δ above and calculate its value, and we arrive at the expression

$$\Delta = \frac{\{B\,(Q+S)+Q\,(R+S)\}\,\{G\,(R+S)+R\,(Q+S)\}}{S}$$

We have now, by substitution of this value of Δ in the value obtained above for z, an expression for the value of the average current through the condenser when the bridge is balanced, and it is

$$z = \frac{ES\begin{vmatrix} -G, & -R \\ Q+S+G, & -S \end{vmatrix}}{\{B\,(Q+S)+Q\,(R+S)\}\,\{G\,(R+S)+R\,(Q+S)\}}$$

Equating this to the other value for z, namely,

$$z = nKe$$

[and substituting the value of e already found, we get finally]

$$nK = \frac{S\,\{S\,(Q+G)+(R+B)\,(Q+S+G)\}}{\{B\,(Q+S)+Q\,(R+S)\}\,\{G\,(R+S)+R\,(Q+S)\}}$$

which gives us a value for n K in terms of

B, Q, R, S, G.

Now, it is interesting to note that we may otherwise write the above expression for n K,

$$\frac{1}{nK} = \frac{\Delta}{\delta},$$

where Δ is the determinant,

$$\begin{vmatrix} R+B+S, & -S. & -R+S \\ -S, & Q+S+G, & Q+S \\ -R, & -G, & R\left(\frac{Q}{S}+1\right) \end{vmatrix}.$$

And δ is its first minor,

$$\begin{vmatrix} R+B+S, & -S \\ -S & Q+S+G \end{vmatrix},$$

therefore n K is of the dimensions of a resistance.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

NOTICE.

With this week's number of "The Electrician" is issued the Index to Vol. XV., which our readers should receive GRATIS.

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THE STEAM ENGINE AT THE INVENTORIES.

On Monday next the Inventories will close, the engines will have run their course, and some of the makers will have been glorified; others very much not. Half a year of performance in public has taught engine makers, and those of the public who have cared to learn, a good deal, and many electrical engineers have learned the lesson that has been so freely taught them. There have been many successes and many failures, and electrical engineers are bound to express their sympathy and their gratitude to those who have failed, for the instruction gained in this way is proverbially more indelible than that imparted by success, although no one can congratulate those who have supplied the negative information.

The display of engine power for lighting purposes has been no small thing, for Messrs. Davey, Paxman, and Co. alone supplied over thirteen hundred horse-power, and besides their engines there are, as our readers well know, various engines of different kinds, mostly of small size, and a large proportion of them high-speed engines. A few of the small engines, those of the double acting type, have been doing very well; but the number of high-speed engines that have done well, we regret to say, is for some reason very small. We regret this because a really efficient engine, capable of running long periods at a stretch at high speed is a very desirable accompaniment of a dynamo. To be able to dispense with gearing of all kinds would be a very great boon if it could be done without accompanying losses in efficiency and economy.

We have on several occasions dwelt on the relative efficiency of high and moderate speed engines as proved by their behaviour when doing the work required by the electrical engineer on large installations and running long periods. Three or four years ago, before the very extensive trial had been made of engines in a competitive manner, there seemed reason for hoping that high-class design and workmanship would place the high-speed engine amongst those which the electrical engineer could employ without any question of efficiency and satisfactory working. Expectations have not been fully realised—far from it. He, as a rule, only uses the high-speed engine where he has not sufficient room for a moderate speed engine and its driving belt, rope, or friction gear. Large numbers of high-speed engines have been put into steamships, but the highest speeds are not now generally adopted, although on board large ships engines may be expected to be watched and nursed as much as is necessary. This fact explains to some extent the continued use of small high-speed engines at sea, but at the same time it must be admitted that skilful attention to details and material has done a good deal towards improving their staying power. The experience of all ship-lighting engineers is not the same, and hence it is clear that the high speeds have not been as impracticable as providing more room in some ships. We are, however, here concerned more immediately with the results of a half-year's working of the engines at the Inventories. Here there has been no restriction as to the amount of supervision or of labour expended in keeping the engines in order, while that comparison which is said to be sufficiently objectionable to be stimulating to any who have reason to fear it has done all it could do. The result is the same, the palm for trustworthiness belongs to the moderate speeds.

Engines which would be on the scrap heap in a month if run at four hundred revolutions per minute will success fully run for years if run at one hundred. Many of the engines which caused a great deal of trouble at the Inventories by failure at four or five hundred revolutions per minute would probably run five years without costing five pounds for repairs if their speed had been from 150 to 200 revolutions per minute. The strains that are imposed upon the parts of small engines by these very high speeds are very great as compared with what is generally supposed. The connecting rod, for instance, in a single acting engine is supposed to have a tolerably comfortable time, because its compressive strength alone is brought into play. This, however, is not the case. The transverse strength is severely tested, and not only so, but it takes a good many pounds of steam per hour to do it.

If we suppose an engine to have an 18in. stroke, and to run at 250 revolutions per minute, the crank end of the connecting rod will make 500 strokes of 18in. in the plane of the crank pin path—that is to say, the connecting rod makes 500 angular traverses per minute; so that it is stopped and started 1,000 times per minute. The speed of the crank will be 1,175ft. per minute, and this speed is acquired by the big end of the connecting rod in the period of a quarter of a revolution, or in one thousandth of a minute; or a speed of 196ft. per second is acquired in 0·06 of a second.

If we suppose the engine to have a horizontal cylinder, so that the rod moves up and down in a vertical plane, it is obvious that gravity comes into play in both the up and down movement, in the former increasing and in the latter decreasing the strain due to the inertia of rest of the rod, which is over-

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THE INTERNATIONAL INVENTIONS EXHIBITION.

The Inventions will not fail to be somewhat more interesting electrically in that various modified forms of the Gramme machine are exhibited. Among the largest exhibitors of this class of dynamo are Messrs. Elwell-Parker, who show eleven dynamos of various powers from 1,500 watts to 50,000 watts, and one six horse-power motor. The largest machine is of the four-pole type, and thus not distinctly on the Gramme lines. Fig. 1 gives a perspective view of this machine. The armature has a core 16in. diameter, 36in. long, and 2in. thick, wound with 186 turns of ·12 wire. At a speed of 450 revolutions per minute the external E.M.F is 110 volts. The exciting coils of the field-magnet are 14in. long, and each is wound with some 2 cwt., giving a little over 3,400 turns of ·058 wire, and has a resistance of 72 ohms. The arms are coupled parallel. They can of course be so coupled as to make both poles above the centre line N or S, and both below it S or N, when the machine works like an ordinary two polar dynamo. The armatures of all Elwell-Parker machines are similarly constructed. Figs. 2 and 3 show the method for coiling the core.

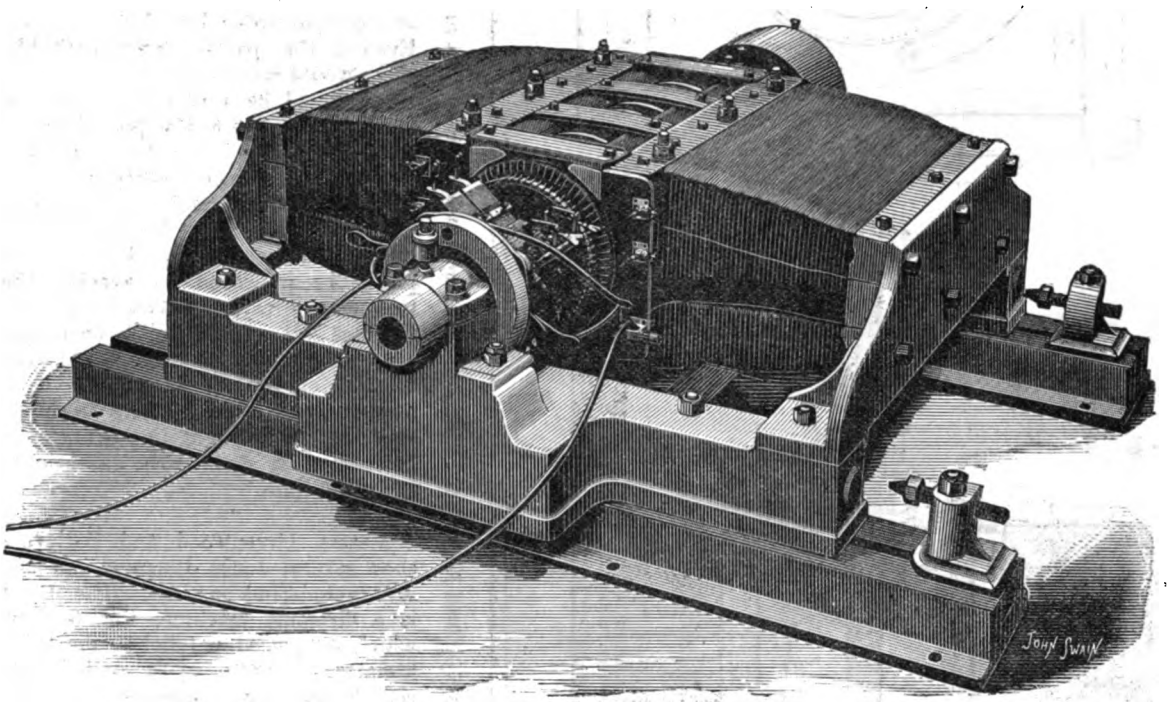

Fig. 1.—Elwell-Parker Four Pole Machine

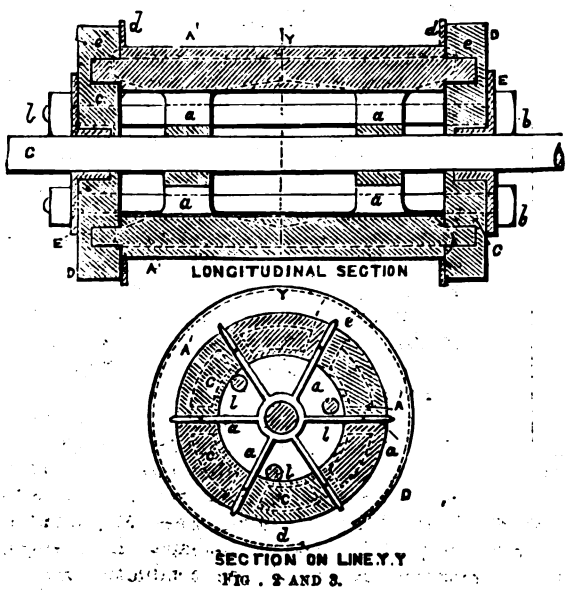

Fig. 2 and 3.

The supporting arms *a a* are keyed to the spindle C, and after having been insulated with tape and fibre—the latter to prevent metallic contact between the core and the arms—the wood blocks A^1 are inserted and held in place by discs D D, into which they are mortised. Three bolts, *b*, keep the whole frame together. To prevent the small lugs or projections *e* coming in metallic contact with the iron of the core, washers, *d d*, of vulcanised fibre are placed one at each end, and the space between them is now completely filled with iron wire coiled on as evenly as possible. In the process of coiling a bituminous compound is applied, which is intended to insulate to a certain extent the wires from each other. After a few layers of wire are coiled on, the surface is tested, and if found out of truth a cut is taken over it. We need hardly mention that the depth of a cut never equals the diameter of the wire, and usually is only a fraction of it. A few more layers are then coiled, and if necessary a cut is taken again, and so on until the core is completed to the right radial depth. In this way a true cylindrical core is obtained. After removing the blocks of wood and insulating the core, it is wound with double silk-covered copper wire in the usual Gramme fashion, but only one layer of wire is used on the out side of the core.

Mr. Kapp, writing of these machines, so far as regards the armature wire, says:—"Most of the modern dynamos contain only one layer of wire on the armature; the Crompton, Edison-Hopkinson, Mather and Platt, and several other machines are constructed in this way; but Messrs. Elwell-Parker have pushed the principle to its utmost limit by making this layer exceptionally thin—in other words, by allowing a high density of current in their armature coils. Most makers regard 3,000 amperes per square inch of conductor a sufficient strain, but in the dynamos under consideration the density is frequently as high as 6,000 amperes. Roughly speaking, we may say that the thickness of the single layer in the Elwell-Parker machine is about one half that found in other dynamos, and in this sense the firm have pushed the single layer principle further than other makers. They maintain that by making the core of small radial depth, so that even the inner coils do not completely fill two layers, the carrying capacity of the wire is considerably increased. The interior of the core is not ventilated, but by a peculiar arrangement on the commutator a current of air is kept flowing into the cavity of the armature at the pulley end, and out between the wires which join the armature to the commutator. This serves to cool the inner wires, whilst the

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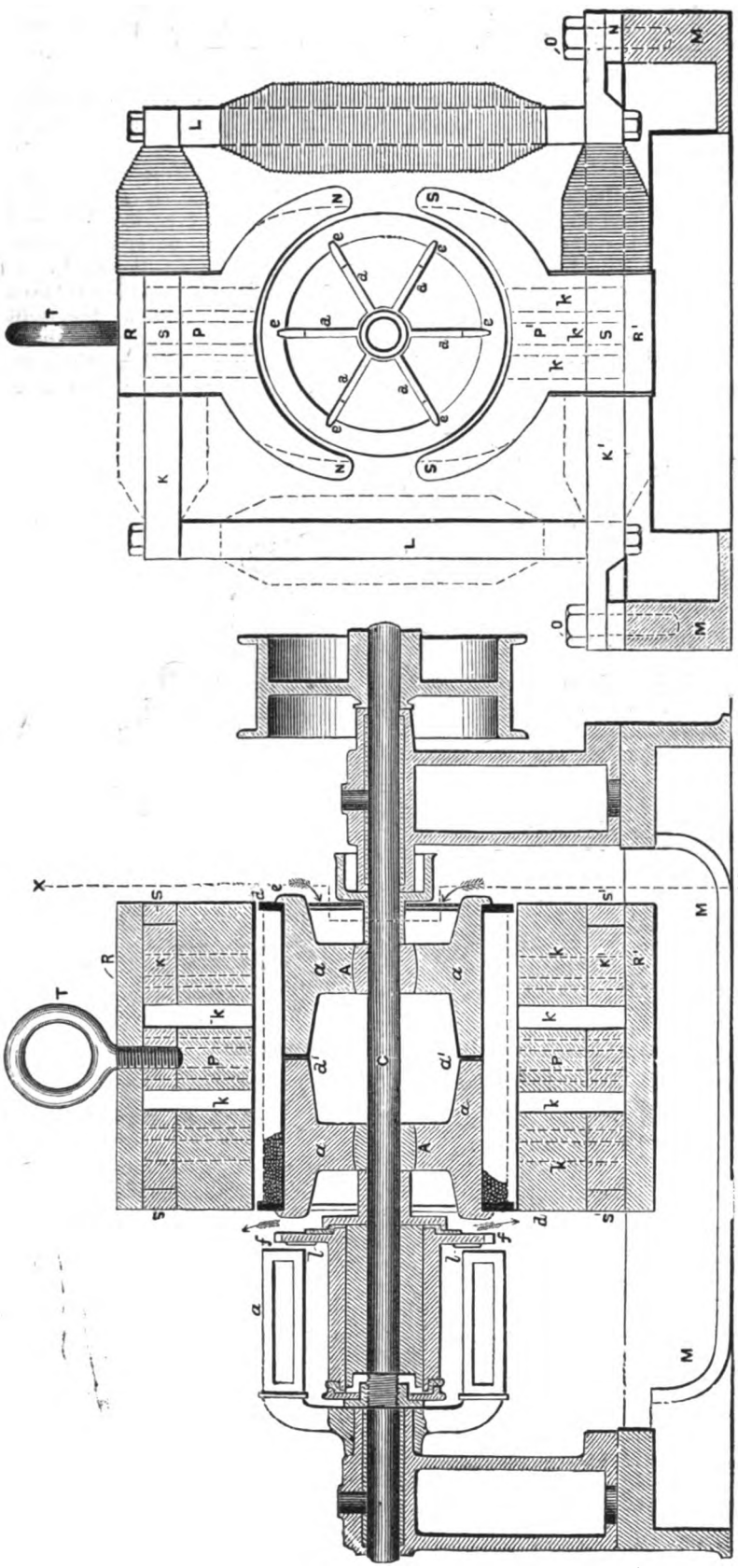
outer turns are kept cool by being whirled through the surrounding air with considerable speed.

"Figs. 4 and 5 show a longitudinal section and an end view of a 6,000-watt machine driven by a Willans engine. The supporting arms, or 'spiders,' are keyed to the spindle C by the hubs A A. Part only of the core is shown, and the armature coils are left out for clearness of illustration. The dark lines represent the insulation between the arms and core. The field-magnets consist of flat wrought iron slabs, K L, bolted together in the shape of a rectangle, with cast iron pole pieces pinned on in the middle of the top and bottom slabs. A large number of pins, K K, are used, these pins being driven tightly into holes bored out in the pole pieces so as to be in close contact with the metal. By this arrangement it is intended to obtain the magnetic conductivity of wrought iron whilst still retaining the cheaper material, viz., cast iron, for the bulk of the pole pieces. In small machines the frame M M is made of Parker's metal, but in larger machines it is made of cast iron, and packing pieces of non-magnetic metal are inserted between frame and field-magnets. It is of interest to note that the thickness of these pieces need not be very great; at any rate, much less than would be required in an Edison machine of equal size. In the latter the pole pieces themselves have to be kept off the frame by non-magnetic packing, and since the free magnetism is greatest at the poles the magnetic insulation must be correspondingly high. In the Elwell-Parker machine, however, the two portions of the field-magnets which come nearest the frame both belong to the lower pole, and are therefore magnetically at a comparatively low difference of potential. Even if the packing were omitted the machine would still continue to work. The only effect would be a very slight drop of electromotive force, due to the partial muffling of the two lower half coils by direct contact with the frame. The rest of the magnetic circuit would, however, not be altered. The arrangement of magnets adopted by Messrs. Elwell-Parker is certainly very compact, but I think that it might be improved by keeping the vertical magnets a greater distance from the polar extensions N S. As is well known, magnetism is always densest at the corners, and a considerable number of lines of force must be wasted by leakage from these corners to the core of the magnet. Some slight improvement might also be effected by shaping the extensions as shown in dotted lines."



FIGS. 4 AND 5.—Elwell-Parker 6,000 Watt Machine—longitudinal section and end view.

Messrs. Greenwood and Batley, of Leeds, show several Jones dynamos and a number of Armington-Sims engines. The Jones dynamo is a Gramme machine, the field-magnets of which are placed parallel to the spindle. The armature consists of a cylindrical Gramme ring having a core composed of charcoal iron wire insulated by a single covering of cotton, and wound on a flanged mandril, the length being twice the radial depth. It is supported by a number of flat U-shaped webs or arms pushed over from the inside, the inner edge of the arms being taper, and let into grooves on a central hub of fibre. They are held in place longitudinally by being pressed tightly between two gun-metal discs insulated by fibre rings. The webs are stamped out of sheet iron, and it is claimed that they assist in reinforcing the magnetic field. A very good point in the armature is the perfect insulation of the core from the shaft. The armature conductor is a copper ribbon laid on flatwise. The winding is commenced by placing the middle of the total length of ribbon intended for one section against the inside of the core inclined at a slight angle to the axis, so that when the two halves are brought over the outside of the core they miss each other by a small distance, forming two turns side by side on the external periphery. In some cases Mr. Jones inserts troughs consisting of a series of U-shaped iron wires, into which the external layers of the conductor are placed. The coils are connected up amongst each other and with a commutator in the usual manner. Connection with the

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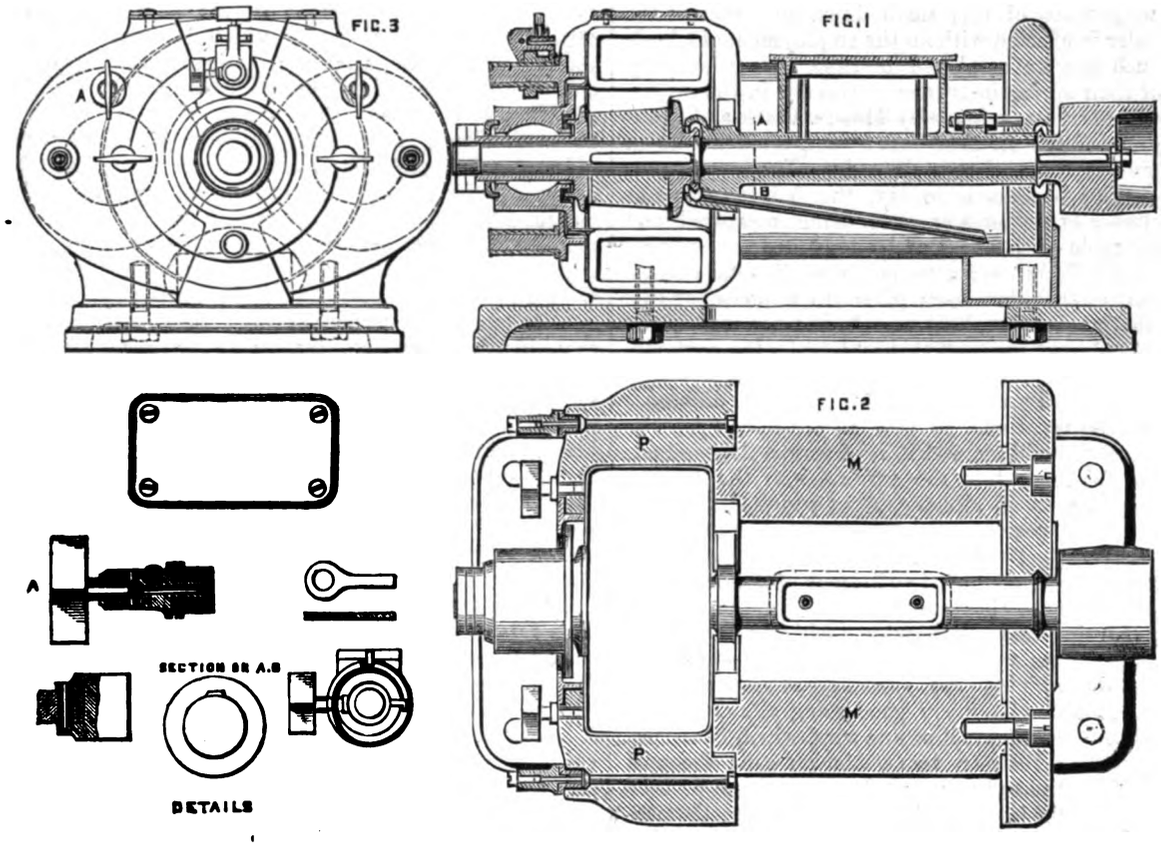
latter is made by a series of L-shaped copper pieces, one end of which is soldered to the radial part of each coil, whilst the other is soldered to the corresponding plate of the commutator. The plates, which against each other are insulated by mica, are made of phosphor bronze, and are arched out internally to reduce their weight. They are held together by two rings of fibre, which are clamped by means of a screw between two flanged discs of gunmetal. The commutator being on the extremity of the shaft is very accessible. The brushes are mounted on insulated ferrules which are fixed to a brass ring capable of being set to any angular position on another brass ring, which at the same time serves as a connecting piece between the two cast-iron pole pieces P P. A salient feature of the machine is the manner in which the spindle is supported. The armature is overhanging, and there is only one bearing of Mitstand metal, the length of it being about 9 diameters. Since the pole pieces partly enclose the armature on its two radial faces, it is extremely important that it should be firmly held in a longitudinal direction, and, if need be, that an adjustment can be made in that direction. For this purpose the yoke end of the bearing is provided with a flange and



adjusting screws, S, by which the whole shaft and armature can be set, so that the clearance on either side of the armature is equal. The magnet cores are two cylindrical bars parallel to the spindle, and joined by a cast-iron yoke. In the machine we illustrate the magnets are placed to the right and left of the spindle, but in larger machines they are placed above and below it. The base of the machine is a plate of zinc.

"We have received permission," says *The Engineer*, to "publish the electrical data of Mr. Jones's 100-light machines, which are as follow:—Current, 64 amperes; electromotive force 100 volts at terminals; speed, 950 revolutions. The armature is wound with flat tape ·22in. by ·07in., or ·0154 square inch, and the density of current is about 2,100 amperes. The core is 14·5in. diameter, 6·5in. long, and 2·75in. deep, giving an effective area of 17·8 square inches. There are fifty-two sections in the commutator and eight turns of conductor to each section, making in all 416 turns counted all round the armature. The perimeter of armature coils is about 22in., giving a total of 250 yards of conductor. Thus at a speed of 950 revolutions 2½ yards of wire produce 1 volt. The calculated resistance of the armature is ·106 ohm, consequently the loss of potential in the armature is 6·85 volts. The cores of the field-magnets are 15·25in. long and 5·75in. diameter, giving an effective area of 26 square inches. Since the lines of force which flow through the armature on both sides of the ring must all come through one magnet core, it follows that the density of lines in armature and magnets is in the proportion of $\frac{26}{2 \times 17{\cdot}8} = {\cdot}73$; hence, if one square inch of armature core carries seventy-three lines, one square inch of magnet core carries 100 lines. The core of the armature is, however, not solid iron, but a number of iron wires placed close together. If we assume that they are arranged on true vertical and horizontal lines, the proportion between gross area of core and area actually occupied by iron is as $4 : \pi$; and consequently the area offered for the accommodation of lines in the core is only ·78 of the gross area, that is, nearly that of the magnet cores. The magnets are compound wound, viz., one layer of ·200 square wire, and twenty-four layers of ·042 round wire. There are sixty-nine turns of main wire on each magnet and the total length of wire on both magnets is 72 yards; resistance, ·043 ohm; density of current in main coils, 1,600 amperes; loss of potential, 2·8 volts. The twenty-four layers of shunt wire have a total length of 7,800 yards and a total resistance of 144 ohms; current through shunt, ·7 ampere; density of current, 500 amperes. From these data we can calculate the electrical efficiency of the machine as follows:—Internal electrical energy, $64{\cdot}7 \times 109{\cdot}65 = 7{,}100$ watts; external electrical energy, $64 \times 100 = 6{,}400$ watts; therefore efficiency $\frac{64}{71} = 90$ per cent. The maximum exciting power of main coils is 7,800 ampere-turns; that of the shunt coils is 8,700; total, 16,500 ampere-turns. The calculated weight of copper on this machine is:—Armature, 43lb.; main wire, 34lb.; series wire, 124lb.; total, 201lb. At 1,000 revolutions per minute the output of this machine would be about 6,800 watts, or about 34 watts for every pound of copper.

This figure might be somewhat increased by allowing a greater density than 500 amperes in the shunt wire. The total weight of the machine is 10cwt.

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Among the apparatus exhibited by Messrs. Latimer Clark, Muirhead, and Co., of Westminster, are some of the electric measuring instruments invented by Profs. Ayrton and Perry, as well as their electric motors. The measuring instruments consist of ammeters, voltmeters, and ergmeters. In the former is employed their "magnifying spring," shaped something like a long, narrow, curled-up wooden shaving, and having the property that if one of the ends be fixed while the other is pulled so as to stretch the spring the latter end rotates through a large angle. This peculiar behaviour, which, of course, does not occur with ordinary spiral springs, arises partly from the way in which the spring is coiled up, and partly from the special dimensions given to the various parts, and formed the subject of a communication to the Royal Society. The spring is stretched by a very thin soft iron cylinder (to which its free end is attached) being pulled into a solenoid wound with wide copper strip in the case of the ammeters, and with fine copper wire in the case of the voltmeters, and although the cylinder is pulled but a short distance into the coil, the pointer moves over some 270° ; hence the instrument is very sensitive. For example, a 20-ampere ammeter will read the 1-10th of an ampere, and a 200-volt voltmeter to one volt. And as the magnifying of this small downward suck of the thin iron cylinder is effected without the employment of wheels and pinions, such as were employed by these inventors in the earlier form of their spring instruments, there is in these magnifying spring instruments made by Messrs. Clark and Muirhead an absence of the friction that accompanies the use of wheels and pinions even when well made. The instruments are "direct-reading,"—that is to say, the pointer points at once to the number of amperes or volts being measured, and no constant nor table of values need be employed.

Profs. Ayrton and Perry's ergmeter measures the total amount of electric energy that has been given to a house, or to a room, during the previous week or month, and not merely the number of coulombs, which is all that is done by the coulomb-meters of Edison, Ferranti, &c.—that is to say, the ergmeter takes account of variations in the potential difference maintained between the mains as well as in the current supplied to the room or building, and it is of course the products of the potential difference into the current into the time, or simply the total quantity of electric energy supplied, that the householder ought to pay for, and not simply the number of coulombs of electricity. The ergmeter can be very conveniently employed in the measurement of the efficiency of accumulators, since the variations in the electromotive forces of the accumulators during charging and discharging—which, of course, is taken into account by the ergmeter in its indications—must not be neglected in determining the efficiency of accumulators. The instrument consists of a fairly good-going clock, the pendulum of which consists of a coil of fine wire, which is a shunt to the house, swinging between two stationary coils of copper strip, through which the main current flows. And the retardations of the clock, as the inventors have shown both mathematically and experimentally, by observations lasting over many months, are directly proportioned to the total quantity of electric energy supplied to the house. When the house is using no electric power, as for example during the day, the ergmeter should go like an ordinary good clock, so that its accuracy can at any time be tested by the user by comparing its rate of going, when no electric power is being used in the house for lighting or other purposes, with that of any decent watch or clock. On the other hand, when electric power is being used in the house the ergmeter loses, and the ergmeters are now so wound that a loss of one minute corresponds with one Board of Trade unit supplied to the house. Hence the user, or the electrical inspector, has merely to multiply the number of minutes the ergmeter is slow by the price agreed on for a Board of Trade unit to settle how much the electric bill should be for the past month or quarter. It does, then, for electricity what a gas meter does for gas; but it does something more—it takes into account, as already explained, variations in the pressure, which no ordinary gas meter does, and hence a similar unfairness in the electric bills cannot be made as was made a year or two ago in the gas bills by the gas companies varying the pressure without reference to the consumers.

This firm are also exhibiting Winter's excellent block instruments, manufactured by them. Neither of the instruments can be put to "clear" or "danger" without the independent action of both signalmen. Should the plunger at either station be depressed by accident, it only strengthens the power which holds the indicator over to the last position.

Mance's submarine telegraph apparatus is also exhibited, and the testing apparatus of Sir Henry Mance, C.I.E., of which this firm are the manufacturers.

The exhibit of the Globe Electrical and Engineering Company, of 20, Dartmouth-street, Westminster, consists of an almost complete display of Mr. Killingworth Hedges' inventions. We have already described his fusible cut-outs, which are of the same pattern as exhibited at the Philadelphia Exhibition last year. A new form of automatic cut-out is now shown, consisting of a weighted lever, which is released by a tripping gear, actuated by an electro-magnet in shunt circuit. A portion of the current is diverted in shunt circuit through a high resistance magnet, which is connected to some part of the line, and gives such a difference of potential as to allow $\frac{1}{3}$ ampere to flow through its coils. Directly the current in the main circuit exceeds a certain amount, the excess which has passed through the shunt attracts the armature, releases the tripping lever, and thus allows the contact piece to be quickly withdrawn, and opens the main circuit, which cannot be established until the current flowing through is reduced. This plan has an advantage over some other kinds of cut-outs, in that, the electro-magnet being placed in shunt circuit, a trifling amount of current, which never exceeds in practice half an ampere, is enough to put in action the tripping gear, and thus control any number of lamps. The same arrangement is also exhibited applied to a duplex cut-out, in which it automatically inserts a spare mica foil for that fused. The Hedges fuses or mica foils exhibited show improvement on the original design, in which they were too delicate, and occasionally gave way by being roughly handled. They are now made as follows:—The foil, coloured black, composed of pure tin for the small currents and also metal—an alloy of aluminium and tin—for the large, is held between pieces of mica, which allow for its expansion when heated. One piece of mica passing under the contact piece serves to stiffen the foil and protects it from rough usage. Another simple pattern of cut-out is also shown. The mica foils have eyelets, through which a binding screw passes. This arrangement, which admits of a spare fuse being quickly substituted for that melted, was specially designed for Mr. W. H. Preece, electrician to the General Post-Office, who has used it in his house for some time, and who has found it answer its purpose admirably. A special form of connector cut-out, used for uniting the main leads to branch wire without cutting the cable, is worthy of notice. A fusible plug can be inserted by any person, as no screws have to be undone.

Passing from the electrical to a more mechanical exhibit of the Globe Electrical Company, we find Mr. Hedges' most recent invention, namely, a hydraulic speed gauge. The instrument is a removable glass tube, revolving in a metallic case, furnished on the outside with a sliding ring. The tube being partly filled with water when revolved, the water has a tendency to creep up the side of the glass and imprison the air therein, and continues, carrying it down in a parabolic form, which is elongated as the speed increases. The bottom of the bubble gives the speed, which is easily ascertained by getting two fine wires of the sliding ring in a line, the revolutions being marked on the case. This instrument has been investigated mathematically, and a formula has been devised, by which the angular velocity of the water, which causes the depression, can be ascertained without experiment, as the depression is always proportional to the speed, so that the calibration of the instrument is simpler than many other forms of speed indicators. Mr. Hedges' instrument should prove of great utility for registering the speed of locomotives, and may perhaps be adapted for ship work. One of these indicators is at work in the electric light shed on the stand of Messrs. Goolden and Trotter.

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come at so high a velocity. The velocity of 196ft. per second is acquired while the big end is falling 9in, or 0·75ft. For a fall of 0·75ft. gravity would give a velocity of 7ft. per second, so that the transverse stress on the rod due to inertia is proportionate to the difference between 7 and 196, and is thus enormously greater than is usually supposed. It may also be observed that as a question of work these very high speeds come injuriously into play. The work done in putting a piston and connecting rod into motion is given out again on the crank at the other end of the stroke, but the work done by gravity on the rising and falling connecting rod is not only not balanced as the crank tends to leave the rod behind it, but it is very insignificant as compared with the work done by the crank in moving it up and down. As above mentioned, the velocity given to the rod is 196ft. per second, while the velocity due to gravity in 0·06 second is but 1·53ft. per second. The crank has thus to pull the rod down as well as raise it. The stroke assumed, 18in., is perhaps large for most of these high speeds, but the speed, 250, is much less than is common, and the strains increase rapidly with the speed, and the lost work also increases.

This is only one detail; but strains cannot be brought to bear on one part alone, and what we have said is merely an example of the extent to which inertia comes into play with high speeds, causing heavy strains on material and wearing surfaces, and representing beside this not a little lost work. There is much to be done yet in these engines, but until better results are forthcoming electrical engineers will no doubt cling to moderate speeds wherever they can be used. At the Inventories, the large engines of this class have run without a hitch, while the high-speed engines have almost all caused delay and annoyance by break down of some kind. The moral is obvious, but the improvements which have been made permit us to indulge in the hope of more.

CORRESPONDENCE.

A PHENOMENON OF CURRENT INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As Mr. E. A. Williams (p. 472) now explains his object and ideas, it would appear that the first thing to be determined is a question of fact rather than an explanation. Facts are preferably ascertained by experiment rather than by evolution from the inner consciousness, or by the old metaphysical processes. Mr. Williams says he believes "in a stronger primary current when the secondary wire is closed as lying at the foot of the matter." Now, as the subject interests him, I would suggest that he should ascertain, first, whether this increased current does really occur, and then reason from that fact; the experiment is worth making, because it involves some important principles. It is also a very easy one to make. It only requires the primary circuit to be broken mechanically by an independent break instead of by the magnetism of the core. A toothed wheel, driven by clockwork, will answer, or a mechanism which I have used myself. This is an ordinary brake, the vibrating spring of which is provided with two screw contacts insulated from each other. The spring is connected to the zinc of two distinct batteries:—1. A Daniell cell, to give perfect constancy, passes its current to one screw-point, and through it to the electromagnet, which actuates the brake. 2. The battery, which through the other screw, works the coil, of which the usual brake is screwed down and fixed. If the current of this battery also passes through a galvanometer, any changes due to opening or closing the secondary circuit will be visible at once.

Now, I will venture to prophecy that the primary current will be *reduced* when the secondary circuit is closed, and I will explain why. We are afflicted with a great many words in electricity, names not of things or phenomena, but of theoretical conceptions—mere artificialities. "Self-induction," of which we hear a good deal, and as to which there are some suggestive remarks (p. 468), is, in my opinion, one of those words which conveys an erroneous idea as to the facts; it implies, what is in fact often stated, that the current passing in the various turns of a coil of wire reacts upon itself, and *induces in its own wire* a reverse E.M.F., or, as is sometimes asserted, a reverse current—the so-called "extra current" of closing circuit. I do not believe any such counter E.M.F. or current exists at all; the facts which lead to this interpretation are merely one result of a general law, operating in many other ways, but apt to be forgotten in the isolating of each of its actions, and the creation of a name and a separate theory for each of them.

Every molecule of matter is what it is, and is placed as it is, under the action and equilibrium of many forces, and any new force coming into action involves a motion of either the masses or molecules of matter within its scope.

The production of an electric current is the evidence of the action of such new forces, and involves a disturbance of the equilibrium of the molecules, not only of its conductor, but of all surrounding matter, in which it sets up the magnetic state, as well as the condition of static electric stress. These conditions involve an expenditure of energy, stored up in the rearranged molecules, by action against the previously existing forces. These forces give up this stored energy, when the molecules return to their first condition, under their influence, on the removal of the disturbing force.

I consider that what is called "self-induction" is simply this absorption of energy in setting up the magnetic charge—that is to say, it is an effect of the coils of wire, *not upon each other, but upon the enclosed air*, &c. As a certain fact, it varies in the same coil with the nature of the material contained in such a coil. It is this energy, stored in the magnetism of the core of a coil, reacting upon the wire of the secondary circuit (itself also having had its molecular arrangement disturbed by the presence of the current in the primary), which generates current in both primary and secondary at moment of "break."

I think a little consideration will show Mr. Williams that the reasoning of the latter part of his letter does not take all the facts into account. Thus, he thinks "the secondary circuit, when not complete, is *not* a circuit; but we know that it *is* a circuit, as a spark crosses. It is a circuit of which part is "inductive," and only transmits current when the E.M.F. created is capable of breaking through the resistance. That is what I meant when I said the energy is engaged in setting up E.M.F., for that exists whether current is actually generated or not. But this inductive element exists in both primary and secondary circuit, and in each it is alike manifested by the presence of the spark. The whole question, as I have before said, is the proportionate division of the energy between the two circuits, and its power of developing in each an E.M F. proportioned to the resistances. This latter is very great in the secondary; and great as is the wire resistance of the latter, it is trifling compared to the external R_1 under ordinary conditions. When this is eliminated by closing the wire circuit, the secondary resistance is probably a trifle compared to that of the primary, with its air space. Hence with the high E.M.F. set up in the secondary, I say that under these conditions nearly the whole of the energy passes to the secondary wire. There it develops an infinitesimal current, which has but a small reaction upon the core, which is at once demagnetised, while the energy is transformed into heat in the secondary wire.

I may go a step further, and say that it is probable that the closing of the secondary circuit will reduce the primary current. In fact, if we can build up the coil by degrees, while the intermittent current is sent into the primary wire mechanically, as before described, we should have four separate causes of diminution of current—each a distinct "retardation" due to energy abstracted in producing molecular stresses (magnetism or E.M.F.).

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1. Let the primary consist of two wires, side by side, and wound upon a cylinder, connected so as to reverse the direction of the current, thus neutralising magnetising actions or so-called "self-induction;" we should have the normal current due to the time during which the brake remains closed, and a very trifling spark, if any.

2. Connect the two wires so as to carry current in one direction; we should have a lessened current. The air and tube are now magnetically and electrically charged, taking up energy. This action may be measured as, or called, either a counter E.M.F. or an added resistance. It is *work to be done by the current*, which is therefore retarded, and in consequence diminished during the time of closure.

3. Slip on the secondary with circuit open.

4. Close this circuit.

In each we give further work to do, in 3 we charge the wire, in 4 we produce an actual current in it.

All this is, in fact, worked out (p. 275) of my "Electricity" (second edition), and the experiments there described are, in principle, the same as the one just supposed, but worked out in a different manner.—Yours, &c., J. T. SPRAGUE.

THE IDENTITY OF STATICAL AND CURRENT INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The unorthodox view on Current Induction which I ventured to suggest in your issue of Oct. 23 being not altogether unimportant in its consequences, especially in its deadly antagonism to the *rationale*, not to the facts, of Lenz's law, will you permit me to bring it before your readers in a more forcible and persuasive manner.

A statement at variance with sanctioned theories has little claim upon our consideration unless supported by cogent arguments; and, indeed, I feel that I owe a great many apologies in presenting to your readers so new a departure in electrical theory, which at the very outset represents an induced current as flowing at one part of its course in a direction contrary to that which has been assigned to it, and as flowing there, ignored by electricians, under circumstances when no current is supposed to exist.

Perhaps the following investigation may help to explain my inclination towards an unusual view. It is an observed fact that a primary current in A B, as shown, induces by its present influence a momentary current from *a* to *c* and from *c* to *b*. What takes place in *a d b* is, as far as I am aware, mere hypothesis, and not the result of any kind of observation. Thus all that we can with certainty infer from the actual facts observed is, that the influence of the primary has been such as to cause high potential at *a* and low potential, relatively, at *b*. Let us, for clearness sake, deal with one of these extremities singly, say *a*. Now, I can only conceive of two ways in which the electric potential at any point of a body can be affected. One is by importing a *charge*, positive or negative; the other is by constraining or expanding the electric *capacity* at that point. Accordingly there are only two ways in which the potential at *a* can have been raised. The first of these supposes the influence of the primary, acting through the dielectric, to consist, as it were, in a backward *wafting* of electricity from *b* to *a*. This would be raising the potential by *importation of charge*. The other way in which the potential at *a* might be raised is by *diminishing the capacity* of the conductor at that part; and if this really were the nature of the influence exercised by the primary, having in view the decline of potential therein, then current induction and statical induction would be identified as one and the same physical process, which is surely a happy conclusion to arrive at. We need not, however, base the argument upon the happiness of its conclusion; it is easy to see how to make our choice between the two possible processes of disturbed equilibrium. If the influence of the primary consisted somehow in a backward wafting of electricity from *b* to *a*, the secondary current would flow on continuously, which is not the case. If the influence consists in modifying the capacity of the neighbouring conductor, as in statical induction, then the decline of potential along the primary wire would be accompanied in the other wire by a less and less constrained capacity from *a* towards *b* throughout the portion subject to influence. The declining slope of potential resulting from this unequal capacity would be adjusted, once for all, by a momentary flow of electricity from *a* to *b*, whether by *a d b* alone, or also by the channel *a c b*, when the secondary wire is a complete circuit; and this theoretical result is in accordance with the observed facts.—Yours, &c., E. ALDRED WILLIAMS.

37, Burlington-road, W., Oct 31, 1885.

CORRECTION.—In Mr. A. Bernstein's letter, published in our last issue, the date of the patent should be *1882* and not *188-* as printed.

THE DISTRIBUTION OF ELECTRICITY.

BY PROF. GEORGE FORBES.

LECTURE III. *(Concluded from page 477.)*

The wires which conduct the electricity into a house of any of these high potential schemes can never have a greater difference of pressure between them than what is required for the lamp; that is, in the present state of affairs, something like 100 volts. We will say that is the highest pressure there can exist between the two wires, and it seems almost incredible that there should ever be allowed to be a leak in the system so great that when a person touches one of the wires he should have a high current flowing through his person which would be dangerous. If we are to abolish the idea of using high potentials simply because of this vague notion that some time a shock might be experienced, we might as well abolish the whole system of gas lighting because it is possible that people can go into rooms where there is a leakage of gas with a lighted candle. The danger from gas is infinitely greater than that which can ever come from high potential electricity, and the difficulty of detecting a leakage of gas is likewise infinitely greater than the difficulty of detecting a leakage of electricity. A properly organised system of distribution of electricity at high potential would render a severe shock to any person absolutely impossible, and that is the point which needs to be dealt on very strongly at present, because so much has been talked—and so much nonsense has been talked—about the dangers of high potentials.

I have often found a great convenience in describing the effects of electricity and the systems of distribution by reverting to the analogy of water pressure, and I think those of you here who are not deeply conversant with the subject of electrical engineering will perhaps be assisted by a few words of reference to the analogy of water pressures.

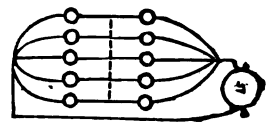

FIG. 1.—Multiple Series.

At present we see through different parts of London pipes being laid for supplying power by means of water at high pressure. This water is utilised in motors or turbines, through which the water passes. The water pressure is remarkably analogous to the pressure of the electricity in our mains; the turbines or other motors which are used to develop the power have remarkable analogy to the incandescent lamps or the arc lamps, or the electric motors which may be used with a system of distribution. Now, in the manner of laying pipes for water-power which we have all observed in the streets in London, all these turbines or water engines are connected directly on to the same set of pipes; in other words, they are all connected in multiple arc, as we would say in electric language. But it would be quite possible to conceive of two turbines connected together in series; that is to say, with a very high pressure in the mains first driving through one of these turbines, and then the outflow of water from that turbine still admitting of considerable high pressure to a second turbine, which it would work with the superabundant pressure which would exist. This is exactly analogous also to the electric system of distribution in series; and this will be clear by examination of the diagram (Fig. 1), where this circle represents the dynamo machine with the two leads coming from it, and here are a number of circuits, each circuit having two lamps in series. This is exactly equivalent to a main to come along here, split into a number of water pipes, with two turbines put in series. It follows that the pressure of water required to drive these two turbines is double the pressure required to drive the one. So it is exactly the same in electric distribution. We simply have to increase the pressure when we put a large number of lamps in series.

Now, there are several different ways in which high potentials can be used effectively and with economy. I will begin with mentioning the probable future which there may be in the application of secondary batteries. We often hear it remarked that the present systems of electric distribution are weak in some points, and that if only a system of secondary batteries were introduced everything would be clear; and there is no doubt that by introducing secondary batteries a great deal of facility is

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given to the scheme. In the first place you can have a much smaller engine power, much smaller dynamo power, because your dynamos can be working the whole day charging these accumulators, and only used for supply when it is required. In the second place, you can put your secondary batteries all in series over a large district, and charge them all up in series, and then discharge them each to its local district, a small number at a time, and a small number at one place. In this way, by using high potentials, of course we should use small currents. In the hydraulic analogy, by using high pressures we require a smaller volume to flow, and therefore we should require smaller conductors, and consequently there would be a saving in laying down our copper. This is perfectly true, and there is not the slightest doubt a secondary battery system is of the utmost value, and would help us enormously. But at the present moment there are several difficulties in the way of introducing secondary batteries like this, and the first is, perhaps, the most fatal one, and that is that we have no secondary battery. I do not mean to say that much has not been done in the last four years in improving secondary batteries; but at the present time we have not sufficient confidence in the length of life and economy of secondary batteries to justify any engineer in depending upon them in designing a scheme of distribution. But I must say that there is a great probability of something being done in this direction, because there is such a vast amount of intellect in the whole world being devoted to this particular line, trying to perfect it, and already I have seen such enormous improvements in secondary batteries of late, that I cannot help thinking that very likely soon we shall arrive at something much more near perfection; and for this very reason I consider it is of the utmost importance that engineers should consider all such schemes which enable them to use high potentials, because, even though at the present time such a scheme as that introduced is imperfect to a certain extent, those schemes which lay down small wires for using with high potentials are the very schemes which will become applicable when the secondary battery is really a commercial thing in our possession; and, therefore, any person who has at the present moment to lay down a large system of lighting with the multiple arc system, would perhaps find, in the course of a year or two, that the whole of this enormous cost of copper he had laid down would be utterly wasted, because some discovery which had been made would enable him to use smaller conductors. For this reason I consider in designing a scheme of electrical distribution an engineer should consider the great importance of probable discovery in the way of secondary batteries.

There has been one large experiment in the way of secondary batteries made at Colchester, and I have got diagrams here showing schemes of electrical distribution. With respect to the diagram at the other end of the room, which was referred to in the first lecture, I would simply say if you have troughs, or good-sized channels, in which your conductors are laid, there is very little difficulty about your insulation; with a good trench and plenty of room, the engineering difficulties are comparatively trivial, so long as you will remember the facts which I pointed out in my first lecture, that you are not to trust your insulating material as the support for the conductor. Your conductor must be supported by a substance capable of supporting it, not by a bituminous compound through which the conductor will sink in the course of years. But there are no engineering difficulties if you are able to have a dry trough for conducting your wires, and I am perfectly of opinion that if you have the mains laid down in that way you can use your 5,000 volts with perfect facility, and there will be no danger; and with proper tests regularly made such a system would not only be possible, but perfectly safe. The following arrangements are made at Colchester by the South Eastern Brush Company for distributing their electricity. The dynamos with the charging mains act through what is called a rocking switch into the secondary batteries. Now in this supply system, first we have charging mains coming to the secondary batteries situated in different districts through the town, and then from the secondary batteries we have service mains going away to different houses which are to be supplied, and this rocking switch is controlled by what is called a master cell, which is simply a cell with a diaphragm, so that when the ebullition of gas becomes too great, and the diaphragm is raised and the contact is made—which switches over this rocking switch, and the cells then being considered to be thoroughly charged, are transferred from the charging system of mains to the service system of mains. This is the arrangement which was adopted there.

One of the cells which are used there is shown here—one of the Consolidated Company's cells—which I have lately had the opportunity of testing very carefully, and which seem to give fair results; and I have upon the tables below two plates, a positive and a negative plate, and you can examine them and see how they are constructed. Let me put in a word here in parenthesis. I do hope that those who are electricians will not allow the term negative to be applied to what ought to be positive, and the term positive to what ought to be negative. I cannot understand why, since secondary batteries have been introduced, the whole language which electricians have been accustomed and got habituated to should be utterly reversed, and if certain companies who make these batteries persist in calling the plates in that way I do not see why electricians should adopt them, and why they should not stick to the terms they have been accustomed to use. I only hope a word said in season here and there will lead to electricians insisting on proper terms being given to these plates. Here, also, I have some plates well worthy of examination kindly lent me by the Electrical Power Storage Company. I may say that I had the good fortune to look through the work they have been doing of late, and I have been very much struck by the enormous progress they seem to have made in the practice of the construction of cells, and the maintenance of them in good order, and the prevention of the sulphating of these plates, which has been a source of very great trouble; and one of the chief things I was shown was the way in which these negative plates are kept in good condition, and how it is apparently impossible to injure them by overchargiug. I believe I am right in pointing to this one [indicating a cell on the table] as one which has been persistently overcharged with the idea of trying to damage it, trying to make it worse, and if you look at it you will see as good a plate as you ever saw in your life in any secondary battery, the material perfectly sound and excellent. It really seems to show that one of the chief difficulties that has been met with is charging with too weak a current, and allowing the battery to degenerate, and not keeping it thoroughly charged up.

Next, I wish to draw your attention to a system of supply with high potentials which has been introduced by means of secondary induction currents. It is a very old idea to use induction currents in order to use a high potential current in the mains, and a low potential current in the supply service. I believe that the first patent which I have come across taken out in connection with this was by Mr. Harrison, in the year 1857, and since then it has been patented over and over again, and here is a general idea of it shown in diagram (Fig. 2), where there are supposed to be rods of iron surrounded by coils of the main wire; here is the main wire coiling around one end of these iron bars. The lamps, then, have their terminals connected by a wire which coils around the iron bar also, an alternate current is used to pass through these main coils, and it sets up alternate magnetisation in opposite directions by these iron bars, and the magnetisation induces electric currents in this wire which is connected with the lamp, and, consequently, we are able to magnetise this bar by the main wires with any potential that we please, and we are able to draw off, by these induced currents, a current of any potential that we please. In this way different lamps in different parts of the circuit can be fed with a current of whatever pressure you please, although the main exciting current is of very high pressure indeed; but, mark this, there is absolutely no danger in this system, because the charging current is in a closed circuit which never goes near the rooms where the lamps are actually at work; a lamp thus never has over the potential which is required for that lamp, and the high pressures which are used in the mains are confined simply to a closed circuit of wire; therefore there is absolutely no danger in such a system so far as the conduction of electricity to any person is concerned. I may say that, owing to the construction of such apparatus, it acts as a condenser, and so might give a severe shock. But this danger can be reduced to limits of safety, and tested for safety by ordinary electrical methods. I have said that this is a very old system. The idea is very

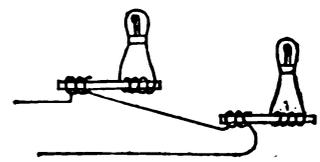

FIG. 2.

old; but it is only in the last few years that it has been worked out practically and with confidence, with a confidence that does honour to M. Goulard, I may say, for the way in which he has attacked this problem; he was confident from the very first. I think it was three or four years ago when we first saw his apparatus in the Westminster Aquarium; since then he has been improving it, and has brought it to a practical issue. Since then I have not myself had the opportunity of experimenting upon the apparatus, but I simply draw my conclusions from the reports, in the first place, made by Dr. Hopkinson and others; and I have not the slightest doubt that from these secondary generators it is possible to get a return of 90 per cent. in the lamp circuits. This is a result which is very remarkable, and is worthy of far more serious consideration than it has received up to the present time from most people, though of course many advanced electricians have been looking with eager interest at the result of these experiments. During the course of the last summer experiments were being made, as most of you are aware, at the Electrical Exhibition at Turin, and I have on the wall a plan of the scheme which was used there, and of the way in which the wires were used. Altogether the circuit had a length of about fifty miles; and we have evidence of the large number of different kinds of lamps used upon that circuit—a large number of Bernstein, Swan, Siemens, and Edison lamps, arc lamps and glow lamps—a large number of different lamps of different pressures, all worked from that central station over that great distance, so that the matter of distance is apparently overcome; these distances were of course much greater than they need be in any town distribution. I do not think I will say anything more about the system just now, except this, that if there is no difficulty about the expense, it is well worthy of far more attention than has been given to it up to the present. I had the pleasure of looking at the installation which is being commenced at the Grosvenor Gallery the other day, and I see there is no doubt we shall have an opportunity very soon of seeing a very large installation there, and at the Inventions Exhibition there is going to be a considerable amount of work done by the same system. After those two experiments we shall be in a position to judge whether economically it is good. In every other point, except perhaps the induced currents which the alternate current machines may create in telegraph wires and other circuits, there really seems to be no objection to the system. It is true there is a great objection to alternate current machines, but when we come to examine it there is very little ground for these objections; if the leading and return wires are brought very close together, induction in neighbouring telegraph

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wires is small, and I really think that we ought to look—all electrical engineers ought to look—very closely into these experiments which are being made just now, for they really promise well.

Now let us go on to the other systems, and which are more analogous to those which we have been describing previously; and first, let us speak of the multiple series system. Here is a system, which I have alluded to, of multiple series on which there are two lamps on every series (Fig. 1). Now the trouble of that was, when it was first introduced, that if one of those lamps went out, the other in the series went out. In order to prevent that, it was suggested to bring a wire connecting the intermediate position to all the lamps in the circuit. Then if one goes out, the other does not, because it is fed by the current coming from the other lamps. The sketch shows that very well by the dotted line. Another example shows it in a different manner. There we go through successive pairs of lamps, the pressure gradually falling as we go along, and pass through the nine different series connected up. I do not know when this system was first proposed; it is very old, I believe. The first time that it was practically seen in action was, I believe, at the Paris Exhibition of 1881, when Mr. Edmunds lighted the Congress Salon by Swan lamps, the lamps all being fitted in multiple series in this manner. After that the most important experiments made were those by Mr. Preece, at Wimbledon, last year, when, in some experiments he made for the Commissioners of Sewers, he lighted up a large part of Wimbledon with incandescent lamps, all on the multiple series system; and quite lately we have had brought before our notice by Mr. Kierzkowski-Steuart an admirable account of the lighting of Temesvar, in Hungary, by means of a multiple series system like this. Now, the multiple series system is one which is admirably adapted to Temesvar, in Hungary, because it is only used there for street lighting, and the lights are always all required at the same time. But it is not suitable for house-to-house distribution, simply for the reason that if some of the lamps are put out, then the other lamps on the circuit have too much current. [Experiment to show this effect.] Now it would be intolerable, in a general supply of electricity, that when one house in a block of buildings was using rather less current than usual, other persons in that block should get far too much current; and that the next block of houses should receive so little current as was shown by these lamps in the experiment would also be intolerable. Various devices have been proposed for getting over these difficulties. I will deal with one or two. The first system which I shall speak of is one which has already been put into practice, and it is undoubtedly a most ingenious principle. That is what is called the three-wire system, which Dr. Hopkinson originated. There we have two dynamos at the central station working in series, working through each other; that is to say, in the hydraulic analogy two pumps working in series, so as to send the water from the pumps at a very high pressure, if such a thing could be introduced into hydraulic engineering. The supply mains come from the extremities of two wires, but there is a third supply main which comes from the intermediate point and connected between the two dynamos, and the lamps are attached to branches which may come from the first main to the intermediate, or, as it has been called, the compensating main, and some of the lamps are attached to branches which are connected with the last main and the compensating main in the middle. We are able to use twice the pressure by using the dynamos in this way. Of course, a great difficulty, as I have mentioned, would occur were it not for this central connection of the compensating wire; if there are more lamps in use in the first series than in the second series, then it would be necessary to drive the first dynamo so as to give a greater current than the second dynamo is giving, and then by adjusting the pressure of the two dynamos we are able to give a constant supply to both sets of lamps, and at the same time to work them in series. This line on the diagram is supposed to represent a point of very large consumption, such as a theatre, when the wires come, some from the first main and the compensating conductor, and some from the second main and the compensating conductor, but in about an equal number, so that if the lights of the theatre be put out of a sudden, the disturbance in one series of mains will be the same as in the other, and there will not be that change in the light shown you just now.

Now, as to the economy of this system. In the first place you will notice that, as I have arranged it here, which is the manner in which Edison has used it, the fall of potential is at the same rate as it is with the ordinary multiple arc distribution; therefore, according to this way, in which lamps are led off from two pairs of mains at every part, the distance to which these mains can extend is still limited, as it was in the multiple arc system, to 124 yards. But it would be equally possible to use only the first main and the compensating main, up to a distance of 124 yards, and then to use the compensating main and the second, the lower potential main for another 124 yards. Now, as to the economy. A great deal of exaggeration has been introduced in America into the accounts of economy in this system. It has been said that since you are using only half the current when you double the number of dynamos, therefore you halve the size of mains. But then you have three mains instead of four; therefore, they say, you have a gain of 25 per cent. for that reason. But then they also say you have got twice the pressure you had before, and, again, you may halve your mains, and, altogether, they tell you, you can make a saving of copper of 62½ per cent. Now, this may suit American financiers, but it is not electrical engineering. As a matter of fact, in the two cases, with an equal number of lamps, in place of having one dynamo and one pair of mains, I introduce two dynamos and three mains. I have half the current passing through that wire, and, therefore, I may have half the section of it, but there is no further reduction possible. I assume that I may take it for granted that the axiom which we worked out in the first lecture must be accepted as an axiom in all future time—that is, that to get economy in our mains we must use the most economical size of conductor possible. In that case the size of conductor is approximately proportionate to the current it has to carry; therefore, the total amount of copper you have to lay down is simply three-fourths of the mass of copper which would be laid down in an ordinary multiple arc system. At a meeting of gentlemen interested in electricity lately this subject was broached, and I ventured to mention this point then simply because the originator was present, and I may say that Dr. Hopkinson thoroughly coincided with me in the views I have given you, so that the erroneous notion is evidently purely an American idea. If we increase the number of wires from three to a larger number, then we increase the economy; but if all the wires are of the same size, then the limit of economy, the maximum economy, would be to reduce the copper by one-half. But it is possible to reduce the compensating wire, and I should think it might be reduced to one-half, and in that case the limit will be one-fourth; that is to say, when you put a large number of series you will have about one-fourth of the copper which you have otherwise in a multiple arc system. However, if we wanted to be absolutely certain that our lamps would be in perfect working order, and that our conductors would be of suitable size, perhaps it would be right that all these three conductors should be of the same size, because such a consumption might arise. I am not of this opinion; but suppose we say that then would come the question whether it is not possible to devise some other means of reducing the thickness of these intermediate wires—these compensating wires. And this is what Mr. Edison has accomplished, on paper at least. In a very interesting patent which he took out in 1883, he has described a means of switching over the lamps from one pair of mains to the other. Now, I believe there is a great deal in this, and I believe it is possible in this way to make the householders themselves regulate their supply to a great extent. Just think what you do with your own gas. When you first light your gas, if your burners are as bad as burners usually are, your light flares, and you have to turn it down; after a time, when everybody else is using the gas, you have to turn it up again; then, late at night, when everybody has gone to bed and you are hard at work, you require again to lower it. If every householder had a switch, so that he could switch his own lamps on to one pair of mains or the other, when he found his light dull, he would fiddle away with his switch, and in that case he would not only make his own light better, but everybody's else, and every person in the district would be helping the others to acquire the right potential. No knowledge of electricity is required; no householder has to know what he is doing; he has simply to follow the natural instinct which a householder has of fiddling with his gas jet until he gets it to work the best way possible, and thus it is just possible that to some extent that may be of use. Mr. Edison proposed to use this system of switches with the three-wire system in combination with it, so that he will not get a perfect compensation by either the one or the other; by the combination of the two he will get a perfect system and a perfect compensation. He has also proposed, in the same patent, to introduce automatic switches, switches which may be influenced by the pressure of these mains locally, or switches which may be influenced by the person in charge at the engine house, so that wherever there is a deficiency of potential, lamps may be switched over. It is very probable that some development on this line may lead to important results. I have myself tried to extend the system a little, not in connection with the three-wire system, but in connection with the simple two-wire system. I feel pretty certain that the lighting of a town from a central station must be done on some multiple series system until secondary batteries are so economical as to permit the general introduction of such a system as that in use at Colchester. The chief difficulty lies in the fact that each section receives the same current whatever be the number of lamps in use. To obviate the excess of current, we might introduce conductors in those sections where it is required to carry off the excess of current. Thus, we should save the lamps at the expense of energy. These conductors might be in the form of adjustible resistances, acting automatically. This system is wasteful, but there are many cases where, at the present time, it is the most economical. Another plan is to introduce in each section a secondary battery of low resistance, which shall act as a regulator. But secondary batteries are still rather expensive. I have shown a diagram of multiple series arrangement in which two wires go round the circuit with breaks occurring alternately in the two wires. If we alter the position of these breaks we can always have the same number of lamps on each section, and so avoid all excess of current and all waste of energy. [Experiment shown.]

Now, the time has come when we must conclude this course of lectures, and, in conclusion, I have only to say that I think you will all agree with me that when we attack the problem of electrical distribution in a serious vein, we find that it is rather simpler than it seems at the first blush. It has been well said by one of our most distinguished electricians that in the past the distribution of electricity has been the *crux* of electric lighting; it has been there that the difficulty has been. Undoubtedly the Electric Lighting Act has done an enormous deal to hinder electric lighting, but every electrician must admit that there has been a difficulty in the question of distribution; and I think you will all agree that the further we get into it, the simpler are the rules which guide us, and it is only that when schemes have generally been commenced in a slightly haphazard fashion that difficulties of a serious character have seemed to present themselves. In every special district the engineer must use his discretion as to the kind of distribution which he is going to employ. But even in large districts, I think you will all agree that the consideration we have given to it shows that it is a possibility to lay mains on economical principles which shall suffice for lighting large districts, if no undue hindrance is put in the way of enterprising undertakers by the authorities that are in power. The past history of electric lighting has chiefly dealt with the system which I first spoke of in my last lecture, the multiple arc system, but I do not hesitate to say that the future of electric lighting, on a large scale, will deal almost entirely with the systems which have been touched upon to-day. And especially I

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would draw attention to these different schemes and their value, for the reason which I have already mentioned, that in the future we may have inventions in secondary batteries, or we may have other inventions; but whatever invention there is favouring electric lighting, it will be of a natnre suitable for using the thinner conductors which we should naturally lay down with any high potential system which I have spoken of this evening. Therefore the engineer, in designing a system of mains, would have a natural bias towards such thin conductors, such high potential mains; for that reason he would advise it, as well as for other reasons. When we are able to use, as I confidently believe we shall, a pressure of 5,000 volts, we can diminish the thickness of our conductors to one-fiftieth part, and for a district of 50,000 lights we should only require a conductor of about an inch section of copper. When we are leaving the idea of masses of copper of the size of a man's body, and coming down to masses of copper an inch or even two inches in diameter, I think we are really coming to the question of practical electric lighting. And all this has been done—is not merely theoretical; it has been done to a considerable extent already, and that is the direction in which progress is being made at the present time.

I can only say that I hope the parliamentary difficulties which have partly stood in the way of electric lighting in the past will soon be entirely removed, and that others will prosecute the question of electric distribution, so that we may be all thoroughly ready for it when we have greater facilities for electric lighting in the future, because there is not the slightest doubt that the question of distribution had not been sufficiently developed when the Electric Lighting Act was passed; and if we are ready in the future, when those great concessions which must be granted by this or a succeeding Government—because it is simple justice—when those concessions have been granted, let us trust that engineers will be ready, and be able to supply a scheme which is perfectly satisfactory.

COMPANIES' MEETINGS & REPORTS.

Direct Spanish Telegraph Company (Limited).

The twenty-fourth ordinary general meeting of this Company was held at the City Terminus Hotel, Cannon-street, on Friday, the 30th ult., under the presidency of Sir James Anderson.

The MANAGER (Mr. Chas. Gerhardi) read the notice convening the meeting and the minutes of the previous meeting, which were confirmed and signed by the Chairman as correct.

The CHAIRMAN then said: Gentlemen, before moving the adoption of the report, I will, as usual, make a few observations in my own way. All that will be new in them will be with respect to the Telegraph Conference, because I find, looking at what I said last April, that if I repeated now what I said then it would answer, perhaps, quite as well. I observed on that occasion that we were trying all that we could to get a wire through Spain to Carthagena, and a better wire between Madrid and Bilbao; that a commercial treaty was apparently about to be concluded between Great Britain and Spain, and that our traffic had been interfered with owing to the cholera. Now, the Spanish treaty has not come off, neither did we get the line to Carthagena, although, as I told you, we had the greatest influence possible brought to bear on the matter, and spent some money in trying to get it. The cholera also has prevailed ever since, and still worse than before; so that we have not got to any satisfactory point as regards the traffic. In addition to these prevailing misfortunes trade has been very much depressed, as we all know, and our cable broke the other day. I am happy, however, to say that our ship arrived on the spot this morning. She is a very fine vessel, and with an experienced captain and crew. I am in hopes that we shall effect a speedy repair, although the cable is broken in 2,000 fathoms of water. These are the bad sides of the story. We are very sorry for the breaking of this cable, which is perfectly unaccountable unless we assume some convulsion at the bottom of the ocean. It was a new cable, and unfortunately it broke at the very time when traffic was growing. I do not think we have seen such evidence of growth for many years as there has been in Spain for the last few weeks previous to the cable breaking, and, in fact, I do not know any other outcome for this Company than to look forward to growth of traffic. I do not think it is any use beating about the bush, and trying to make the position look pleasanter and nicer than it is. That growth of traffic will come I have great hopes, but if not we shall not pay dividends in a hurry. Mr. Gerhardi and I have been to the Berlin Conference, where we were five or six weeks, and you will naturally ask what was done there. When we went to Berlin the outlook was as gloomy as possible. It seemed that if the tariffs were arranged as Germany and Austria wished, the Direct Spanish Company would have been wiped out, and there was a wide feeling amongst some of the delegates against submarine cables. There was an idea that a great many of the cables were luxuries, and not of very much use—that a few might be, but not many of them. However, that idea ceased to have any great weight in the course of a fortnight or so. They began to find that for external commerce cables were not only not a luxury but were indispensable, so much so that they had to be termed and were termed the "normal routes." This country, which has practically all its commerce outside the limits of these islands, has, speaking off-hand, 75 per cent. of the whole telegraphs of the world—I mean the external telegraphs—and therefore we are dependent more than any other country which connects its shores with the shores of other States. We received the cordial support of Mr. Patey, who represented the Post Office; of Colonel Champain, who represented India; and of all those States, such as Spain, France, Turkey and Greece, and others, where private cables are landed, and they insisted on almost all cables being considered as normal routes, because of the frequent interruptions of the land lines, and because—seeing that these cables are worked by private hands, and under the ocean, not traversing a number of States speaking different languages—our cables are the most reliable, with the fewest errors. There therefore came to be a better feeling towards us (because the delegates were business men) as we mingled among them. And I must speak in praise of the assiduity of Mr. Gerhardi, who speaks several languages, and who mixed among them in the most genial way, getting more out of them I think than any other Manager at the conference. In order to make the cables pay, those States in which the cables were landed had to raise their rates so as to give them something, and they did so in such a way as to make us very little, if any, the worse for what was done. All through the published records of the receipts of the different telegraph administrations there is nothing but deficits, except in the case of a few States. One country loses £210,000, and there are other countries losing £50,000 to £60,000, and five of the larger States have fused their postal and telegraph receipts so that no one can can tell how much they are losing on the telegraph returns, and they cannot be called in question by their own taxpayers. There is this peculiarity in the Direct Spanish Company and with the European cables of the Eastern Company, that we are opposed to Governments who not only have monopolies, but can afford to lose money, or think they can do so, on their telegraph administration. At all the conferences I have been at in the last fifteen years the governing principle as regards telegraph administrations was that the revenue must pay the expenses, and upon that basis the tariffs were adjusted. But Germany has insisted for some years—and especially at this conference—that that should not be the governing principle. The desire, in fact, of all European States, as you know, arising from the colonial fever, is to extend commerce outside their own limits, and, by bringing down telegraph tariffs to a minimum, to increase the facilities for supporting that commerce between distant colonies, and outside countries and centres from which manufacturers and emigrating populations arise. It was therefore the great aim and effort on the part of Germany and Austria, and some of the other States, to disregard the tariffs of almost everyone, and to bring down the cost of telegrams to a price which they, however, soon saw, when it came to be discussed, would not allow those cables to be maintained, and the result happily was that they recognised that principle, and the tariffs were so adjusted that I do not think this Company will lose much, if anything. The whole aggregate loss that we can see is about £1,400. Notwithstanding all that these States are losing, they are still prepared to lose 40 per cent. more, because that is what the present tariffs amount to; and, assuming that these low tariffs will increase the number of telegrams, I do not think we shall lose anything on the whole. Our tariff will now be 4½d. instead of 6d. a word to Spain. That is the position in which we stand with regard to the Telegraph Convention. I really do not see, as I have said, anything to improve this Company without an increase of traffic to a large extent. We can carry four or five times as much traffic as I have yet seen, so that we have plenty of carrying power. With these remarks I now move the adoption of the report. I do not think I have anything to add unless you ask me questions which may induce me to say something further.

Mr. EDMUND ETLINGER seconded the motion.

In answer to Mr. DYETT, who asked when the old cable might be expected to be at work,

The CHAIRMAN said that they must proceed cautiously, and not be in a hurry to spend a lot of money on what might prove not worth repairing. The Eastern Company lost an excellent ship last year, which the Directors would have employed on this work, but he had not thought it proper or wise to recommend his colleagues to spend money in chartering another vessel to send out for the purpose of repairing the cable. The captain of the vessel had great doubts of its being repaired, and he (the Chairman) would not like to attempt it now, being winter time; and until the summer came he desired not to make any promises in respect to the subject.

Mr. BEARD thought the sooner they dropped the old cable the better.

The CHAIRMAN: I do not think we are prepared to do that.

Mr. COCHRANE asked—what he said he had done at the previous meeting—whether the Chairman would submit the precise opinion upon which the Board had decided not to pay the preference dividend. He complained of the lack of interest in the Company shown by the shareholders, as was evidenced by the paucity of the attendance. The proxies, he went on to say, showed that they were in the hands of the Eastern Company—a very excellent company—but he ventured to submit it was rather a precarious thing to have two representatives of the Eastern Company on their Board, and only one gentleman representing the Direct Spanish shareholders. He thought the time had come when there ought to be some change in the constitution of the Board. As to employing a ship belonging to the Eastern Company to repair their cable, if he was not in error, by the constitution of the Company Directors who were also members of other companies were precluded from voting on such a question, and how, therefore, could a majority of the Board vote on it? It seemed to him that the only hope for the Company was to be absorbed by the Eastern Company. He confessed his amazement that the Eastern Company should hold something like £100,000 of their capital, and that no steps had been taken by the old Board to better protect the shareholders from being so utterly bound over. They could never, he thought, pay a dividend to the common shareholders until their capital was made intact, which could only be effected in two ways—either by replacing their broken cable, or reducing their capital. He was strongly of opinion that a committee should be appointed to meet the Directors and consider the whole question.

The CHAIRMAN, in reply, said that for his own part he would be very glad to be turned out of his seat. He did not go on the Board willingly, or for any purpose of his own. As for the ship, he was quite certain that the Eastern Company did not wish to give them a ship; and if it were

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not that they were so largely interested in the prosperity of the Direct Spanish Company, they would not get the ship at the price they were getting her for or for anything like it. Anyone with the slightest experience of shipping might see at a glance that the same terms could not be offered by any Company making money out of its ships. The Eastern Company made no money out of the Direct Spanish. The former, as he had said at the last meeting, had an object in buying shares in the latter, and that was an object which, if realised, would have been the making of the Direct Spanish Company. If they had twenty committees matters could not be mended. If the Eastern Company could have taken one of their cables to Carthagena, to connect it with Bilbao, it would have been the saving of the Company, and he was in hopes of doing it yet. No one else could do it but the Eastern Company; and, moreover, it would pay no other Company to do it. They got Sir Robert Morier to exert himself on their behalf, and that gentleman was authorised to do so by our own Government. If the shareholders wished to get a committee to manage the Company he was willing to resign, and unless he were patted on the back he would rather not be on the Board. The only way of making money for the Company was by developing traffic in some way. He could not take any blame to himself for contracts of the old Board. The old cable was far too overladen with capital. It was not represented by that, and never was. He would not move a finger to be kept on the Board. The Directors were doing the best they could, and he defied anyone to do better. He had no personal interest to serve by remaining on it.

Mr. ETLINGER, as a member of the old Board, said that the interests of the Company were looked after by the two gentlemen connected with the other company in a much better way than any one else could do, on account of their experience in such matters. They had power to help the Company, and they were willing to exercise it. He quite agreed with the Chairman that a committee would not improve the position.

Mr. DYETT said he would be very sorry to lose the services of the Chairman. It seemed to him that the Directors were doing their very best for the Company.

Mr. BEARD expressed a wish to see the Company taken over altogether by the Eastern Company.

The CHAIRMAN replied that it could not be done at the price the shareholders of the Direct Spanish would want.

Mr. COCHRANE repeated his question as to the opinion on which it was decided not to pay the preference dividends.

The SOLICITOR (Mr. Blunt) read the substance of the opinion of Mr. Horace Davey, Q.C., to the effect that the Directors could not properly pay a dividend on any of the shares, including preference shares, until they had either put the original cable into a proper state of repair and working order or abandoned it altogether, and taken the necessary legal steps to write off the capital represented by that cable as lost capital unrepresented by available assets.

The CHAIRMAN said that this subject had engaged the attention of the Directors a great deal. They had been enjoined against paying dividends. Anyone could buy a share in the market, and could hold the Board personally liable for the payment of dividends. This had been the case in the Anglo-American Company, where the Directors had tried to defy such a view, but had been obliged to give in. They had taken counsel's opinion, and no Director would, in the face of such an opinion as they got (which was only one of a number), take the personal responsibility of being liable to pay back dividends which had been distributed.

The SOLICITOR here pointed out that Mr. Davey had also said that no valid distinction could be made between preference and ordinary shareholders.

Mr. COCHRANE remarked that he asked the question because at the last meeting and since some of the shareholders thought that if the extra capital were called up the Directors were released from that liability.

The CHAIRMAN pointed out that they had only £12,000 to call up, which he did not think could be used for any other purpose than that of laying land lines in Spain.

The motion was then put, and carried unanimously.

Mr. DYETT urged the Board to exercise all the economy they could under the circumstances in which the Company is placed, and suggested that in future the Company's meetings should be held at their own offices.

The CHAIRMAN said the Directors had themselves made the same remark before the meeting, but on this occasion they expected a larger attendance of shareholders anxious to hear what the conference had done.

Mr. STOKES proposed and Mr. DYETT seconded a vote of thanks to the Chairman, which was cordially agreed to, and

The CHAIRMAN having briefly replied, the proceedings terminated.

Eastern Extension, Australasia, and China Telegraph Company (Limited).

Report and accounts of the Directors for the half year ended 30th June last, to be presented to the twenty-fourth ordinary general meeting, to be held at the Cannon-street Hotel, on the 10th inst., at two o'clock:—

The gross receipts, inclusive of Government subsidies, have amounted during that period to £259,476. 9s., against £237,672. 11s. 5d. for the corresponding period of 1884, showing an increase of £21,803. 17s. 7d. The working and other expenses, including £23,406. 15s. 6d. for cost of repairs and renewals of cables and expenses of ships, absorb £74,418. 6s. 9d., against £66,658. 18s. 9d. for the corresponding half year of 1884, leaving a balance of £185,058. 2s. 3d. From this is deducted £3,104. 15s. 4d. for income tax, and £41,595 for interest on debentures and contributions to sinking funds, leaving £140,358. 6s. 11d. as the net profit for the half year, against £127,415. 15s. 8d. for the corresponding period of 1884. Against this the Directors have charged a further sum of £20,000 on account of the partial renewal of the Singapore Saigon and Penang-Rangoon cables. The cost of the operations will be shown in the accounts for the current half year, the whole of the cable not having been picked up before the 30th June. One quarterly interim dividend of 1½ per cent., amounting to £31,250, has been paid during the half year, and another of like amount, together with a bonus of 2s. per share, was distributed on the 15th ultimo, making a total payment of 3½ per cent. for the half year, leaving £32,858. 6s. 11d. to be carried forward. In accordance with the provisions of the trust deed, dated 10th May, 1879, 239 Five per cent. Australian Government Subsidy Debentures were drawn on the 29th April last for payment at par on the 1st July. A new cable steamer, "Recorder," has been built for the Company by Messrs. R. Napier and Sons, to replace the ss. "Magneta." She is now fitting out in the Thames, and will shortly be despatched to Singapore. No serious interruptions have occurred during the half year, although the Company's ships have been employed on various repairs. They have also been employed on charter to the Telegraph Construction and Maintenance Company for a considerable period, as shown in Abstract C. At the same time, 322 knots of cable, taken principally from the Company's stock at Singapore, were sold to that Company. The latter transaction will appear in the current half year's accounts. All the Company's cables are now in good working order. At the International Telegraph Conference recently held at Berlin, several important questions were discussed affecting the telegraphing public, but the principal changes made in the existing convention were in the direction of cheapening the European tariffs. The new convention will come into force on the 1st July, 1886. The question of reduction of rates has been under the consideration of your Board for some considerable time, and at the conference it was agreed to make certain reductions to Australia and China on condition that the Indian and South Australian Governments reduced their transit rates. The South Australian Government have agreed to bear their share of the reduction, and negotiations with the same object are proceeding with the Indian Government. The land line between Port Darwin and Adelaide, belonging to the South Australian Government, has, as usual, worked well during the half year under review.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. Nov. 4.		BUSINESS DONE WEEK ENDING NOV. 4. Highest.		Lowest.	
Anglo-American	31½,	32½	..... 32½	.....	31⅞	
Do. Preferred	53½,	54½	..... 55½	.....	53⅞	
Do. Deferred	8⅞,	9½	..... 9½	.....	9	
Brazilian Submarine	11¾,	11⅞	..... 11⅞	.....	11⅜	
Cuba	12½,	12½	..... 12⅝	.....	—	
Do. Preference	18,	19	..... —	.....	—	
Direct Spanish	1½,	2	..... —	.....	—	
Do. Preference	11½	11⅝	..... —	.....	—	
Direct United States Cable	9⅛,	9⅜	..... 9½	.....	—	
Eastern Telegraph	11⅜,	11½	..... 11⅝	.....	11⅜	
Do. 6 per Cent. Preference	13½,	14½	..... 13½	.....	—	
Do. 5 per Cent. Debentures, 1899	105,	108	..... —	.....	—	
Eastern Extension	12⅜,	12½	..... 12½	.....	12⅜	
German Union	9½,	10	..... —	.....	—	
Globe Telegraph and Trust	7,	7½	..... 7½	.....	7	
Do. Preference	13⅛,	13¾	..... 13¼	.....	13⅛	
Great Northern	13½,	14	 14	.....	13⅜	
Indo-European	31,	32	..... 31½	.....	31½ x.d.	
Reuter's	7⅞,	8	..... 7⅞	.....	7 9-16	
Submarine	205	215	 211	.....	210	
West India and Panama	⅞,	1	 15-16	.....	13-16	
Do. 1st Preference	9½,	9⅞	..... 9⅞	.....	9½	
Western Brazilian	5½,	5⅞	..... —	.....	—	
Western Union 7 per Cent. 1st Mortgage	117,	121	..... —	.....	—	
Do. 6 per Cent. Sterling Bonds	100,	104	..... —	.....	—	

TELEPHONES.

Consolid. Telephone and Maintenance	¾,	1	 15-16	.....	—	
Oriental	3-16,	5-16	..... —	.....	—	
United Telephone	12,	12½	.....12 5-16	.....	11 13-16	

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1⅞,	2½	..... 2½	.....	—	
Do. (fully paid)	3½,	4	..... 3¾	.....	3⅝	
Hammond Light (£3 15s. paid)	1-16	3-16	..... —	.....	—	
Swan	⅛,	¼	..... —	.....	—	
Maxim-Weston	3-16,	5-16	..... ¼	.....	—	

MISCELLANEOUS.

Telegraph Construction	36,	37	..... 36¼	.....	36¼	
India Rubber, Gutta Percha, and Telegraph Works	23½,	24½	..... 24½	.....	23½	

TRAFFIC RECEIPTS FOR OCTOBER, 1885.

COMPANIES.	Oct., 1885.	Oct., 1884.	Increase.	Decrease.
Cuba Submarine	2,100	2,230	—	130
Direct Spanish Telegraph	1,748	1,816	—	68
Eastern Telegraph	56,994	53,865	3,129	—
Eastern Extension	43,936	41,357	2,629	—
Great Northern	24,400	—	—	—

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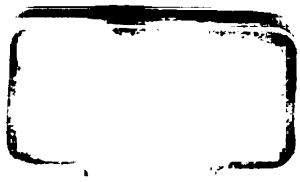

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